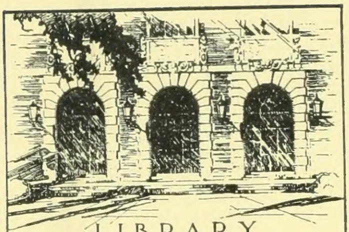


THE

American Geologist

A MONTHLY JOURNAL OF GEOLOGY

AND

ALLIED SCIENCES

VOLUME XVII

January to June, 1896

Minneapolis, Minn.
The Geological Publishing Company
1896

The Franklin Printing Co., Printers

CONTENTS

JANUARY NUMBER

FEBRUARY NUMBER

MARCH NUMBER

APRIL NUMBER

MAY NUMBER

JUNE NUMBER

THE AMERICAN GEOLOGIST,
Vol. XVII, Plate I.

THE

AMERICAN GEOLOGIST.

VOL. XVII. JANUARY, 1896. NO. 1.

JAMES DWIGHT DANA.

By CHARLES E. BEECHER, New Haven, Conn.

[Portrait, Plate I.]

Professor Dana often said that of all the natural sciences, geology most interested him. He explained this preference on the ground that it gave him the widest mental scope and involved more profound problems than the cognate sciences. This disposition in favor of geology finds further and more conclusive support in the number of publications he issued relating to his favorite science, for out of two hundred titles of books and pamphlets written by him, more than half relate to geology alone. Therefore the world's estimate of the man will be as a geologist, notwithstanding the many valid claims of zoölogy and mineralogy, for in these sciences, also, his many and extensive works fully entitle him to rank as an authority.

"Geology is all the sciences combined into one" was a remark of his, and gave his interpretation of the nature of his many-sided science. And no American has yet dealt with the subject from so many points of view. There is, however, a manifest tendency or preference shown in his works toward generalization and the consideration of the grander theoretical and philosophical problems relating to the earth's history.

The evolution of the continents, the history of the oceanic basins, mountain building, the Glacial period, coral islands, and volcanoes were subjects which most attracted him, and inspired a large number of his separate papers.

The study of these broader aspects of geological history was taken up early in life and continued almost without interruption. Previous to 1850 appeared articles on "The areas of subsidence in the Pacific, as indicated by the distribution of coral islands," "The volcanoes of the moon," "The origin of continents," "Geological results of the earth's contraction in consequence of cooling," and "Origin of the grand outline features of the earth." About forty papers on the same or kindred topics appeared after 1850, and give farther emphasis to this general character of his geological studies. Even in the last five years of his life, and forty years after the publication of the papers above cited, we find him still progressive and active along the same lines of thought, and writing on "The origin of the deep troughs of the oceanic depression. Are any of volcanic origin?," "Characteristics of volcanoes, with contributions of facts and principles from the Hawaiian islands," "Archæan axes of eastern North America," "Rocky Mountain protaxis and the post-Cretaceous mountain making along its course," "The genesis of the heavens and the earth and all the host of them," "Features of non-volcanic igneous ejections as illustrated in the four rocks of the New Haven region," and "On New England and the Upper Mississippi basin in the Glacial period."

It is not difficult to explain this broad scope of subjects, for it is undoubtedly due to his early personal familiarity with most of the prominent features of the earth's surface. Even before graduation from college, he made a cruise through the Mediterranean, visiting the seaports of France, Italy, Greece, and Turkey. Five years later, in 1838, he was appointed mineralogist and geologist to the United States Exploring Expedition under Wilkes and for four years travelled extensively, for the most part in the southern hemisphere. The expedition visited both coasts of South America, many of the islands of the South Pacific, Australia, New Zealand, thence north to the Gilbert archipelago, the Caroline islands, the Sandwich islands, and the coast of Oregon. Here, after suffering shipwreck and the loss of personal property and some of the collections, he travelled overland to San Francisco. The return to New York was by way of the Sandwich islands, Singapore, the Cape of Good Hope, and St. Helena.

Seldom has it been the good fortune of a young man to be placed in actual contact with such varied aspects of nature. At that time many of the islands were almost unknown, and few of them had felt the disturbing influences of modern civilization, so that, practically, everything was new and offered the richest opportunity for study and observation. In this connection it may be recalled that quite a number of notable men of science of this century have had similar natural instruction through extensive travel. Darwin, just before, had traversed some of the same regions and independently both worked out the same theory to explain the origin of coral islands. Humboldt, Huxley, Hæckel, Agassiz, Moseley, and Thompson had similar opportunities for extensive observation, and their works show the influence of this most liberal kind of education.

It must not be imagined that all Dana's geological work was of a general nature. He spent much time, and published numerous papers embodying the results of his investigations in the field, on the glacial phenomena of New England, the geology of the New Haven region and the questions involved in the Taconic controversy which led him into a detailed examination of the geology of Berkshire county, Massachusetts, and Westchester county, New York. His zoölogical works on the Crustacea and Zoöphytes are more extensive than on any other subject, but they were not carried through life in the same active manner as his geological studies.

One of the most striking qualities of the man, indicating his greatness as well as his mental activity and vigor, was the ability to keep in adjustment with the progress of much of the leading thought during the long and revolutionary period in which he lived. Those who knew him personally or as a correspondent probably realize this to a greater degree than those who judged of his opinions only through the periodic publication of his larger works. Nearly all the debatable and unsettled problems of geology were constantly uppermost in his mind and received the test of each new discovery of fact as soon as announced. The gradual advance and establishment of the doctrine of evolution in opposition to special creation has probably required a greater mental elasticity and equilibration on the part of the men who bridge the transition period than any intellectual revulsion of modern times. Dana's attitude on another question applies equally well here. In the preface to the third edition of his mineralogy, in 1850, he says that "To change is always seeming fickleness. But not to change with the advance of science is worse; it is persistence in error."

The first edition of the *Geology* (1862) clearly teaches the doctrine of special creation for the many successive floras and faunas in the geologic ages. It is now interesting to note the changes made in the wording of a single paragraph of this work through its separate editions. Others of a similar nature could be selected but the following is sufficient. In the general remarks at the close of the chapter on the Devonian age he says (1st ed., p. 304), "Each period had its new creations and its extinctions, and often, also, there were many successive creations and extinctions in a single period." Twelve years afterward, while the law of evolution was being attacked on all sides, the corresponding paragraph of the second edition (p. 289) is noncommittal, merely stating the facts without any reference to the underlying cause, showing that the author was awaiting the result of the conflict and unwilling as a teacher to espouse either. It reads, "Each period had its new species or tribes and its extinctions, and often, also, there were many successive faunas in a single period." The third edition is essentially the same here, though in other parts of the book advances are made toward the acceptance of the law. The last edition (1895) and the final work of his life is everywhere built upon the central idea of evolution. It dominates and colors his entire thought and in the paragraph corresponding to the one already cited (4th ed., p. 630) we find that, "The progress of the systems of life through the Devonian era was continued into and through the following era without any abrupt transition."

His willingness to modify his views in accordance with right methods and with the demands of science is further shown in his works on mineralogy. The *System of Mineralogy* through its successive editions mirrors all the changing aspects presented by this science for more than half a century. Nothing could be more radical than the transition from the natural-historical system with its binomial nomenclature to the crystallo-chemical system now in use. Yet it was done, not gradually, but all at once, as is stated in the preface to the third edition, "notwithstanding the former adoption of what has been called the natural history system, and the pledge to its support given by the author in supplying it with a Latin nomenclature, the whole system, its classes, orders, genera, and Latin names have been rejected, and even the trace of it which the synonymy might perhaps rightly bear has been discarded."

Thus it is that Dana's text books have shown such life. Their author was not satisfied with a mere reprint for a new edition, but each underwent revision, and was an advance over the preceding. His active mineralogical studies were practically suspended after the publication of the fifth edition of the *System of Mineralogy* in 1868, in which he enlisted the aid of Professor George J. Brush. The subsequent thorough editing and revision of this great work has been carried on by his son, Edward S. Dana.

President Dwight, who is most familiar with and competent to speak of his work as a teacher, says, "In the later years he gave instruction only in geology. The students were, however, glad to meet him when the privilege was given them, and no man in the company of teachers stood higher in their esteem both for character and attainments. They felt, as they saw him, that they were in the presence of a master in science and of one who honored the institution and themselves as he lived in the academic community. He had the ardor of youth in his studies and in his instructions, even to the latest period of his active service. Notwithstanding the long-continued interruptions which he experienced by reason of ill-health, he always returned to his work, even on partial recovery, with full enthusiasm. His walks with selected students in the country region about New Haven, and the teaching which he gave as he moved from point to point, will ever be remembered by those who shared in the pleasant excursions. As a lecturer he was attractive. His style was clear and impressive; his language admirably chosen; his manner adapted to his subject and material; his whole presentation of his thoughts and views thoroughly characteristic of a truly scientific man. He had a mingling of the poetic element in his writing which gave an interest to what he said, and at times he rose into eloquence. His lecture on Corals and Coral Islands, which he often repeated at the earnest desire of successive classes of students, will long be remembered with peculiar pleasure by all who listened to it."

Some mention should be made of the honors received, all of which came unsought and were valued chiefly as a recognition and appreciation of work done. Professor Dana was awarded the Wollaston medal from the Geological Society of London, in 1872, the Copley gold medal from the Royal Society of London, in 1877, and the Grand Walker prize from the Boston Society of Natural History, in 1892. The degree of Ph. D. was conferred by the University of Munich in 1872 and that of LL. D. by Amherst College in 1853, and by Harvard and Edinburgh in 1886. He was elected president of the American Association for the Advancement of Science in 1854, and was a corresponding or honorary member of most of the leading learned societies of the world.

The main events of his life have been fully recounted elsewhere, and also summaries and estimates of his work have been given. The fullest account of his life is the one published by Edward S. Dana in the May number of the American Journal of Science for 1895. President Dwight has ably described his relations to Yale University in a memorial address commemorative of Professors Dana and Whitney, before the graduates, June 23d, 1895, and since printed in pamphlet form. His work as a geologist is treated at some length by Henry S. Williams, in the Journal of Geology, for Sept.-Oct., 1895, and his characteristics as an educator are discussed by O. C. Farrington in the same journal for April-May, 1895. In the present sketch but a brief outline of his life is given.

James Dwight Dana was born in Utica, New York, February twelfth, 1813. He came to New Haven, Connecticut, in 1830, and entered Yale College with the class of 1833. Here he enjoyed the scientific advantages then offered by the elder Silliman. The years from 1833 to 1842 were largely spent in travel with the expeditions already mentioned. The following thirteen years were mainly devoted to the study of the collections made by the Wilkes' expedition, and to the preparation of the extensive and classic volumes on the geology, zoöphytes, and crustacea. In 1844 he married Henrietta Frances, third daughter of Professor Benjamin Silliman. He was editor of the American Journal of Science from 1846 to the time of his death, and contributed to this repository of American science about one hundred and fifty scientific articles, besides hundreds of reviews and miscellaneous notices. He was appointed professor of natural history in Yale College in 1850, and in 1864 the title was changed to that of professor of geology and mineralogy. With brief interruptions, due to ill health, he gave instruction in the class room until 1890, when again from failing health he was compelled to relinquish active college work and in 1894 he was made *Professor Emeritus*. After his retirement, he devoted nearly all his remaining energy to the completion of the enormous task of wholly revising and rewriting the *Manual of Geology* and of successfully carrying it through the press. This volume of more than one thousand pages was presented to the public in February, 1895, and two months later, on the fourteenth of April, its distinguished author and teacher passed away, at the age of eighty-two years.

BIBLIOGRAPHY.*

1835. On the condition of Vesuvius in July, 1834. *Amer. Jour. Sci.*, (1), vol. 27, pp. 281-288.

A new system of crystallographic symbols. *Ibid.*, vol. 28, pp. 250-262.

1836. A new mineralogical nomenclature. *Amer. Lyc. Nat. Hist. N. Y.*, vol. 4, pp. 9-34.

On the formation of compound or twin crystals. *Amer. Jour. Sci.*, (1), vol. 30, pp. 275-300.

Two American species of the genus Hydrachna. *Ibid.*, pp. 354-359.

1837. A system of mineralogy: including an extended treatise of crystallography; with an appendix, containing the application of mathematics to crystallographic investigation, and a mineralogical bibliography. New Haven, large 8vo, xiv + 580 pp.

Description of the Argulus catostomi. *Amer. Jour. Sci.*, (1), vol. 31, pp. 297-308.

On the identity of the torrelite of Thomson with columbite. *Ibid.*, vol. 32, pp. 149-153.

On the drawing of figures of crystals. *Ibid.*, vol. 33, pp. 32-50.

Crystallographic examination of eremite. *Ibid.*, pp. 70-75.

1838. Description of a crustaceous animal belonging to the genus Caligus. *Ibid.*, vol. 34, pp. 225-266.

*Reprinted with slight changes and additions from "Bibliographies of the Present Officers of Yale University," New Haven, 1893.

1843. The analogies between the modern igneous rocks and the so-called Primary formations. *Ibid.*, vol. 45, pp. 104-129.

On the temperature limiting the distribution of corals. *Ibid.*, pp., 130-131.

The areas of subsidence in the Pacific, as indicated by the distribution of coral islands. *Ibid.*, pp. 131-135.

1844. A system of mineralogy. 2nd edition, 640 pp., 8vo, New York and London.

The composition of corals. *Amer. Jour. Sci.*, (1), vol. 47, pp. 135-136.

1845. Observations on pseudomorphism. *Ibid.*, vol. 48, pp. 81-92.

Origin of the constituent and adventitious minerals of trap and the allied rocks. *Ibid.*, vol. 49, pp. 49-64.

1846. Zoöphytes. [U. S. Exploring Expedition.] Philadelphia, 4to, 741 pp.; with a folio atlas of 61 plates. [Under C. Wilkes, U. S. N.]

Notice of some genera of Cyclopacea. *Amer. Jour. Sci.*, (2), vol. 1, pp. 225-230.

General views on the classification of animals. *Ibid.*, pp. 286-288.

On the occurrence of fluor spar, apatite and chondrodite in limestone. *Ibid.*, vol. 2, pp. 88-89.

The volcanoes of the moon. *Ibid.*, pp. 335-355.

1846-1847. Zoöphytes. *Ibid.*, pp. 64-69; pp. 187-202; vol. 3, pp. 1-24; pp. 160-163; pp. 337-347.

1847. The origin of continents. *Ibid.*, vol. 3, pp. 94-100.

Geological results of the earth's contraction in consequence of cooling. *Ibid.*, pp. 176-188.

Origin of the grand outline features of the earth. *Ibid.*, pp. 381-398.

A general review of the geological effects of the earth's cooling from a state of igneous fusion. *Ibid.*, vol. 4, pp. 88-92.

Fossil shells from Australia. *Ibid.*, pp. 151-160.

Observations on some Tertiary corals described by Mr. Lonsdale. *Ibid.*, pp. 359-362.

Certain laws of cohesive attraction. *Ibid.*, pp. 364-385.

1847-1851. Conspectus Crustaceorum. I. *Proc. Amer. Acad.*, Boston, vol. 1, pp. 149-155. II. *Ibid.*, vol. 2, pp. 9-61. IV. *Amer. Jour. Sci.*, (2), vol. 8, pp. 424-428. V. *Ibid.*, vol. 9, pp. 129-133. III. *Proc. Amer. Acad.*, Boston, vol. 2, pp. 201-220. VI. *Amer. Jour. Sci.*, (2), vol. 11, pp. 268-274.

1848. Manual of mineralogy, including observations on mines, rocks, reduction of ores, and the application of the science to the arts. New Haven, 12mo, 430 pp.

On a law of cohesive attraction as exemplified in a crystal of snow. *Amer. Jour. Sci.*, (2), vol. 5, pp. 100-102.

1849. Review of Chambers' Ancient Sea-margins, with observations on the study of terraces. *Ibid.*, vol. 7, pp. 1-14: vol. 8, pp. 86-89.

Notes on Upper California. *Ibid.*, vol. 7, pp. 247-264.

Observation on some points in the physical-geography of Oregon and Upper California. *Ibid.*, pp. 376-394.

Synopsis of the genera of Gammaracea. *Ibid.*, vol. 8, pp. 135-140.

Conspectus Crustaceorum, Crustacea Entomostraca. *Ibid.*, pp. 276-285.

Geology. [U. S. Exploring Expedition under C. Wilkes, U. S. N.] Philadelphia, 4to, 756 pp.; with a folio atlas of 21 plates.

1850. A system of mineralogy. 3rd edition, 711 pp., 8vo, New York and London.

Denudation in the Pacific. *Amer. Jour. Sci.*, (2), vol. 9, pp. 48-62.

The isomorphism and atomic volume of some minerals. *Ibid.*, pp. 220-245.

On the genus Astræa. *Ibid.*, pp. 295-297.

The degradation of rocks and formation of valleys of New South Wales. *Ibid.*, pp. 289-294.

Historical account of the eruptions on Hawaii. *Ibid.*, pp. 347-364; vol. 10, pp. 235-244.

Some minerals recently investigated by M. Hermann. *Ibid.*, pp. 408-412.

Observations on the mica family. *Ibid.*, vol. 10, pp. 114-119.

The analogy between the mode of reproduction in plants and the "alternation of generations" observed in some Radiata. *Ibid.*, pp. 341-343.

1851. The markings of the carapax of crabs. *Amer. Jour. Sci.*, (2), vol. 11, pp. 95-99.

The physical and crystallographic characters of the phosphate of iron, manganese and lithia of Norwich, Mass. *Ibid.*, pp. 100-101.

On a new genus of Crustacea. *Ibid.*, pp. 223-224.

Mineralogical notices. *Ibid.*, pp. 225-234; vol. 12, pp. 205-222; pp. 387-397.

Classification of maioid Crustacea. *Ibid.*, pp. 425-434.

Classification of the Cancroidea. *Ibid.*, vol. 12, pp. 121-131.

Conspectus Crustaceorum. Crustacea Grapsoidea. *Proc. Acad. Nat. Sci. Philadelphia*, vol. 5, pp. 247-254.

Classification of the Crustacea Grapsoidea. *Amer. Jour. Sci.*, (2), vol. 12, pp. 283-290.

Conspectus Crustaceorum. Crustacea Paguridea. *Proc. Acad. Nat. Sci. Philadelphia*, vol. 5, pp. 267-272.

Crystallographic identity of eumanite and brookite. *Amer. Jour. Sci.*, (2), vol. 12, pp. 397-398.

1851-1852. Coral reefs and islands. *Ibid.*, vol. 11, pp. 357-372; vol. 12, pp. 25-51; pp. 165-186; pp. 329-338; vol. 13, pp. 34-41; pp. 185-195; pp. 338-350; vol. 14, pp. 76-84.

1852. Classification of the Crustacea Corystoidea. *Ibid.*, vol. 13, pp. 119-121.

Conspectus Crustaceorum. Crustacea Paguridea, Megalopidea and Macroura. *Proc. Acad. Nat. Sci. Philadelphia*, vol. 6, pp. 6-28.

Conspectus Crustaceorum. Crustacea Cancroidea. *Ibid.*, pp. 73-86.

Lettering figures of crystals. *Amer. Jour. Sci.*, (2), vol. 13, pp. 339-404.

On the humite of Monte Somma. *Ibid.*, vol. 14, pp. 175-182.

The eruption of Mauna Loa in 1852. *Ibid.*, pp. 254-259.

Classification of the Crustacea Choristopoda. *Ibid.*, pp. 297-316.

Some modern calcareous rock-formations. *Ibid.*, pp. 410-418.

1853. Coral reefs and islands. New York, 8vo, 144 pp.

Changes of level in the Pacific ocean. *Amer. Jour. Sci.*, (2), vol. 15, pp. 157-175.

The question whether temperature determines the distribution of marine species of animals in depth. *Ibid.*, pp. 204-207.

Mineralogical notices. *Ibid.*, pp. 430-449.

The isomorphism of sphene and euclase. *Ibid.*, vol. 16, pp. 96-97.

An isothermal oceanic chart. *Ibid.*, pp. 153-167; pp. 314-327.

The consolidation of coral formations. *Ibid.*, pp. 357-364.

A supposed change of ocean temperature. *Ibid.*, pp. 391-392.

1852-1854. Crustacea. [U. S. Exploring Expedition under C. Wilkes, U. S. N.] New York, 4to, pt. I, pp. 1-690; pt. II, pp. 691-1620, with a folio atlas of 96 plates, issued in 1854.

1854. A system of mineralogy. 4th edition in two volumes, 320 and 534 pp., 8vo., New York and London.

Mineralogical contributions. *Amer. Jour. Sci.*, (2), vol. 17, pp. 75-88; vol. 18, pp. 249-254.

Contributions to chemical mineralogy. *Ibid.*, vol. 17, pp. 210-221; vol. 18, pp. 128-131.

Homœomorphism of some mineral species. *Ibid.*, vol. 17, pp. 430-434.

The homœomorphism of mineral species of the trimetric system. *Ibid.*, vol. 18, pp. 35-54.

1854-1855. Geographical distribution of Crustacea. *Ibid.*, pp. 314-326; vol. 19, pp. 6-15; vol. 20, pp. 168-178; pp. 349-361.

1855-1856. Supplements to the system of mineralogy. *Ibid.*, vol. 19, pp. 353-371; vol. 21, pp. 192-213; vol. 22, pp. 246-263.

1856. Address before the American Association for the Advancement of Science on retiring from the duties of president. *Proc A. A. A. S. for 1855*, pp. 1-36.

1856. Volcanic action at Mauna Loa. *Amer. Jour. Sci.*, (2), vol. 21, pp. 241-244.

Classification of Crustacea. *Ibid.*, vol. 22, pp. 14-29.

American geological history. *Ibid.*, pp. 305-334.

The plan of development in the geological history of North America. *Ibid.*, pp. 335-349.

1856-1857. Science and the Bible: a review of: and the six days of creation, of Prof. Tayler Lewis. *Bibl. Sac.*, vol. 13, no. 49, pp. 80-129; vol. 13, no. 51, pp. 631-656; vol. 14, no. 54, pp. 388-413; vol. 14, no. 55, pp. 461-524.

1857. Manual of mineralogy. 2nd edition, 455 pp., 12mo, New Haven.

On species. *Bibl. Sac.*, vol. 14, pp. 854-874. Reprint: *Amer. Jour. Sci.*, (2), vol. 24, pp. 305-316.

Fourth supplement to the mineralogy. *Ibid.*, pp. 107-132.

Review of Dr. Kane's Arctic explorations. *Ibid.*, pp. 235-251.

Parthenogenesis. *Ibid.*, pp. 399-408.

1858. Review of Agassiz's contributions to the natural history of the U. S. *Ibid.*, vol. 25, pp. 202-216; pp. 321-341.

Fifth supplement to the mineralogy. *Ibid.*, pp. 396-416.

The currents of the oceans. *Ibid.*, vol. 26, pp. 231-233.

Review of Marcou's Geology of North America. *Ibid.*, pp. 323-333.

Sixth supplement to the mineralogy. *Ibid.*, pp. 345-364.

1859. Synopsis of the Report on Zoöphytes, etc., 172 pp., 8vo, New Haven.

Eruption of Mauna Loa, Hawaii. *Amer. Jour. Sci.*, (2), vol. 27, pp. 410-415.

Antic ipation of man in nature. *N. Englander*, vol. 17, pp. 294-334.

Seventh supplement to the mineralogy. *Amer. Jour. Sci.*, (2), vol. 28, pp. 128-144.

1862. Manual of geology; treating of the principles of the science with special reference to American geological history: for the use of colleges, academies and schools of science. Philadelphia and London, small 8vo, 812 pp.

1863. The higher subdivisions in the classification of mammals. *Amer. Jour. Sci.*, (2), vol. 35, pp. 65-71.

The existence of a Mohawk-valley glacier. *Ibid.*, pp. 243-249.

On man's zoölogical position. *N. Englander*, vol. 22, pp. 283-287.

Two oceanic species of protozoans related to the sponges. *Amer. Jour. Sci.*, (2), vol. 35, pp. 386-387.

On cephalization. *N. Englander*, vol. 22, pp. 495-506.

On cephalization and on Megasthenes and Microsthenes in classification. *Amer. Jour. Sci.*, (2), vol. 36, pp. 1-10.

On the Appalachians and Rocky mountains as time-boundaries in geological history. *Ibid.*, pp. 227-233.

The homologies of the insectean and crustacean types. *Ibid.*, vol. 36, pp. 233-235.

Certain parallel relations between the classes of vertebrates and some characteristics of the reptilian birds. *Ibid.*, pp. 315-321.

1863-1864. The classification of animals based on the principle of cephalization. *Ibid.*, pp. 321-352; pp. 440-442; vol. 37, pp. 10-33; pp. 157-183; pp. 184-186.

1864. A text book of geology: designed for schools and academies. Philadelphia, 12mo, 356 pp.

Fossil insects from the Carboniferous formation in Illinois. *Amer. Jour. Sci.*, (2), vol. 37, pp. 34-35.

1865. The crystalization of brushite. *Ibid.*, vol. 39, pp. 45-46.

Origin of prairies. *Ibid.*, vol. 40, pp. 293-304.

1866. Cephalization. Explanations drawn out by the statements of an objector. *Ibid.*, vol. 41, pp. 163-174.

A word on the origin of life. *Ibid.*, pp. 389-394.

Observations on the origin of some of the earth's features. *Ibid.*, vol. 42, pp. 205-211; pp. 252-253.

1867. Crystallogenic and crystallographic contributions. *Ibid.*, vol. 44, pp. 89-95; pp. 252-263; pp. 398-409.

Mineralogical nomenclature. *Ibid.*, pp. 145-151.

1868. A system of mineralogy: Descriptive mineralogy, aided by George Jarvis Brush. 827 pp., 8vo, New York.

Recent eruption of Mauna Loa and Kilauea, Hawaii. *Amer. Jour. Sci.*, (2), vol. 46, pp. 105-123.

1870. The geology of the New Haven region, with special reference to the origin of its topographical features. *Trans. Conn. Acad. Arts and Sci.*, vol. 2, pp. 45-112.

1871. On the Quaternary or Post-Tertiary of the New Haven region. *Amer. Jour. Sci.*, (3), vol. 1, pp. 1-5; pp. 125-126.

On the supposed legs of a trilobite, Asaphus platycephalus. *Ibid.*, pp. 320-321.

The Connecticut River Valley glacier, and other examples of glacier movement along the valleys of New England. *Ibid.*, vol. 2, pp. 233-243.

The position and height of the elevated plateau in which the glacier of New England, in the Glacial era, had its origin. *Ibid.*, pp. 324-330.

1872. Corals and coral islands. New York, large 8vo, 398 pp.

Notice of the address of Prof. T. Sterry Hunt before the American Association at Indianapolis. *Amer. Jour. Sci.*, (3), vol. 3, pp. 86-93; vol. 4, pp. 97-105.

What is true Taconic? *Amer. Naturalist*, vol. 6, pp. 197-199. *Amer. Jour. Sci.*, (3), vol. 3, pp. 468-470.

Green Mountain geology: On the quartzite. *Amer. Jour. Sci.*, (3), vol. 3, pp. 179-186; pp. 250-256.

On the oceanic coral island subsidence. *Ibid.*, vol. 4, pp. 31-37.

1872-1873. On the quartzite, limestone and associated rocks of the vicinity of Great Barrington, Berkshire Co., Mass. *Ibid.*, pp. 362-370; pp. 450-453; vol. 5, pp. 47-53; pp. 84-91; vol. 6, pp. 257-278.

1873. The Glacial and Champlain eras in New England. *Ibid.*, vol. 5, pp. 198-211.

Results of the earth's contraction from cooling, including a discussion of the origin of mountains, and the nature of the earth's interior. *Ibid.*, pp. 423-443; vol. 6, pp. 6-14; pp. 104-115; pp. 161-172.

On the rocks of the Helderberg era, in the valley of the Connecticut. *Ibid.*, vol. 6, pp. 339-352.

1874. Manual of geology. 2nd edition, 911 pp., 8vo, New York.

Text book of geology. 2nd edition, 358 pp., 8vo, New York and Chicago.

Changes in subdivisions of geological time. *Amer. Jour. Sci.*, (3), vol. 8, pp. 213-216.

On serpentine pseudomorphs, and other kinds from the Tilly Foster iron mine, Putnam Co., New York. *Ibid.*, pp. 371-381; pp. 447-459.

1875. The geological story briefly told, an introduction to geology for the general reader and for beginners in the science. New York, 12mo, 264 pp.

Notice of the chemical and geological essays of T. Sterry Hunt. *Amer. Jour. Sci.*, (3), vol. 9, pp. 102-109.

On Dr. Koch's evidence with regard to the contemporaneity of man and the mastodon in Missouri. *Ibid.*, pp. 335-346.

1875-1876. Southern New England during the melting of the great glacier. *Ibid.*, vol. 10, pp. 168-183; pp. 280-282; pp. 353-357; pp. 409-438; pp. 497-508; vol. 12, pp. 125-128.

1876. "The Chloritic formation" on the western border of the New Haven region. *Ibid.*, vol. 11, pp. 119-122.

On the damming of streams by drift ice during the melting of the great glacier. *Ibid.*, pp. 178-180.

Plants as registers of geological age. *Ibid.*, pp. 407-409.

Note on erosion. *Ibid.*, vol. 12, pp. 192-193.

On cephalization. *Ibid.*, pp. 245-251.

1877. An account of the discoveries in Vermont geology of the Rev. Augustus Wing. *Ibid.*, vol. 13, pp. 332-347; pp. 405-419; vol. 14, pp. 36-37.

The relations of the geology of Vermont to that of Berkshire. *Ibid.*, vol. 14, pp. 37-48; pp. 132-140; pp. 202-207; pp. 257-264.

The Helderberg formation of Bernardston, Mass., and Vernon, Vermont. *Ibid.*, pp. 379-387.

1878. Manual of mineralogy and lithology. 3rd edition, 474 pp., 12mo, New Haven.

On the driftless interior of North America. *Amer. Jour. Sci.*, (3), vol. 15, pp. 250-255.

"Indurated bitumen" in the trap of the Connecticut valley. *Ibid.*, vol. 16, pp. 130-132.

Geology of New Hampshire. *Ibid.*, pp. 399-401.

1878-1879. Some points in lithology. *Ibid.*, pp. 335-343; pp. 431-440; vol. 18, pp. 134-135.

1879. The Hudson River age of the Taconic schists. *Ibid.*, vol. 17, pp. 375-388; vol. 18, pp. 61-64.

1880. Manual of geology. 3rd edition, 912 pp., 8vo, New York.
Gilbert's report on the geology of the Henry mountains. *Amer. Jour. Sci.*, (3), vol. 19, pp. 17-25.
The age of the Green mountains. *Ibid.*, pp. 191-200.

1880-1881. The geological relations of the limestone belts of Westchester Co., New York. *Ibid.*, vol. 20, pp. 21-32; pp. 194-220; pp. 359-375; pp. 450-456; vol. 21, pp. 425-443; vol. 22, pp. 103-119; pp. 313-315; pp. 327-335.

1881. On the relation of the so-called "kames" of the Connecticut River valley to the Terrace-formation. *Ibid.*, vol. 22, pp. 451-468.

1882. The flood of the Connecticut River valley from the melting of the Quaternary glacier. *Ibid.*, vol. 23, pp. 87-97; pp. 179-202; pp. 360-373; vol. 24, pp. 98-104.
Text book of geology. 4th edition, 412 pp., 8vo. New York.
Review of Dutton's Tertiary history of the Grand Cañon district. *Amer. Jour. Sci.*, (3), vol. 24, pp. 81-89.
Southward discharge of lake Winnipeg. *Ibid.*, pp. 428-433.

1883. The western discharge of the flooded Connecticut. *Ibid.*, vol. 25, pp. 440-448.
Phenomena of the Glacial and Champlain periods about the mouth of the Connecticut valley—that is in the New Haven region. *Ibid.*, pp. 341-361; vol. 27, pp. 113-130.

1884. Obituary of Prof. Arnold Guyot. *Ibid.*, vol. 27, pp. 246-248.
Condition occasioning the Ohio River flood of February, 1884. *Ibid.*, pp. 419-421.
On the southward ending of a great synclinal in the Taconic range. *Ibid.*, vol. 28, pp. 268-275.
The Cortlandt and Stony Point hornblendic and augitic rocks. *Ibid.*, pp. 384-386.
Origin of bedding in so-called metamorphic rocks. *Ibid.*, pp. 393-396.
The making of limonite ore beds. *Ibid.*, pp. 398-400.
The decay of quartzite, and the formation of sand, kaolin and crystallized quartz. *Ibid.*, pp. 448-452.

1885. A system of rock notation for geological diagrams. *Ibid.*, vol. 29, pp. 7-10.
The decay of quartzite:—Pseudo-breccia. *Ibid.*, pp. 57-58.
Creation: or the biblical cosmogony in the light of modern science. *Bibl. Sac.*, vol. 42, no. 166, pp. 202-224.
Taconic rocks and stratigraphy. *Amer. Jour. Sci.*, (3), vol. 29, pp. 205-222; pp. 437-443.
Origin of coral reefs and islands. *Ibid.*, vol. 30, pp. 89-105; pp. 169-191.
On displacement through intrusion. *Ibid.*, pp. 374-376.

1886. Lower Silurian fossils from a limestone of the original Taconic of Emmons. *Ibid.*, vol. 31, pp. 241-248.
Arnold Guyot. *Ibid.*, pp. 358-370.

Early history of Taconic investigation. *Ibid.*, pp. 399-401.

General terms applied to metamorphism and to the porphyritic structure of rocks. *Ibid.*, vol. 32, pp. 69-72.

Taconic stratigraphy and fossils. *Ibid.*, pp. 236-239.

A dissected volcanic mountain, Tahiti. *Ibid.*, pp. 247-255.

1887. Manual of mineralogy and lithology. 4th edition, 518 pp., 12mo., New York.

Volcanic action. *Amer. Jour. Sci.*, (3), vol. 33, pp. 102-115.

Taconic rocks and stratigraphy. *Ibid.*, pp. 270-276; pp. 393-419.

1887-1888. History of the changes in the Mauna Loa craters on Hawaii. *Ibid.*, pp. 433-451; vol. 34, pp. 81-97; pp. 349-364; vol. 35, pp. 15-34; pp. 213-228; pp. 282-289; vol. 36; pp. 14-32; pp. 81-112; pp. 167-175.

1888. The cosmogony of Genesis. *Andover Rev.*, pp. 197-200.

Asa Gray. *Amer. Jour. Sci.*, (3), vol. 35, pp. 181-203.

A brief history of Taconic ideas. *Ibid.*, vol. 36, pp. 410-427.

1889. Dodge's observations on Halemaumau. *Ibid.*, vol. 37, pp. 48-50.

Notes on Mauna Loa in July, 1888. *Ibid.*, pp. 51-53.

Points in the geological history of the islands of Maui and Oahu. *Ibid.*, pp. 81-103.

The origin of the deep troughs of the oceanic depression. Are any of volcanic origin? *Ibid.*, pp. 192-202.

1890. Characteristics of volcanoes, with contributions of facts and principles from the Hawaiian islands. New York, 8vo. 400 pp.

Corals and coral islands. 2nd edition, 440 pp., 8vo, New York.

Sedgwick and Murchison—Cambrian and Silurian. *Amer. Jour. Sci.*, vol. 39, pp. 167-180.

Archæan axes of eastern North America. *Ibid.*, pp. 378-383.

Rocky Mountain protaxis and the Post-Cretaceous mountain-making along its course. *Ibid.*, vol. 40, pp. 181-196.

Long Island sound in the Quaternary era. *Ibid.*, pp. 425-437.

The genesis of the heavens and the earth and all the host of them. Hartford, 12mo, 70 pp.

1891. The four rocks of the New Haven region, East rock, West rock, Pine rock, and Mill rock, in illustration of the features of non-volcanic igneous ejections. With a guide to walks and drives about New Haven. New Haven, 8vo, 120 pp.

Features of non-volcanic igneous ejections as illustrated in the four rocks of the New Haven region. *Amer. Jour. Sci.* (3), vol. 42, pp. 79-110.

On Percival's map of the Jura-Trias trap-belts of central Connecticut. *Ibid.*, vol. 42, pp. 439-447.

1892. Subdivisions in Archæan history. *Ibid.*, vol. 43, pp. 455-462.

Additional observations on the Jura-Trias trap of the New Haven region. *Ibid.*, vol. 44, pp. 165-169.

Farther observations on the permanence of oceans and continents. *Natural Science*, vol. 1, pp. 739-740.

1893. On New England and the Upper Mississippi basin in the Glacial period. *Amer. Jour. Sci.*, (3), vol. 46, pp. 327-330.
1894. Observations on the derivation and homologies of some articulates. *Ibid.*, vol. 47, pp. 325-329.
1895. Manual of geology. 4th edition, 1057 pp., 8vo, New York.

PHYSICAL CONDITIONS OF THE FLOW OF GLACIERS.

By Warren Upham, St. Paul, Minn.

(Plate II.)

Historical Introduction.

Chiefly to Louis Agassiz, during the years 1838 to 1847, following lines of study begun by Venetz, Charpentier, Guyot, and others, we owe the geological application of the observations of the work of existing glaciers in the Alps to explain, first, the extension of the Alpine Pleistocene glacial drift across the great valley of Switzerland to the Jura mountain range, and, second, the origin and methods of formation of the Pleistocene drift deposits in the British Isles, northern Europe, and the north half of North America.

On the other hand, we are chiefly indebted for the most important early discoveries and descriptions of the physical structure of glaciers to James David Forbes, during the years 1841 to 1859, working partly in association with Agassiz, but mostly separate and independent, on account of their conflicting claims to certain discoveries, and their different interpretations of the veined structure and methods of flow of glaciers. Guyot and Agassiz considered the lamination of the glacier ice in blue and white bands to be due to the stratification of the high snowfields by the deposition of successive snow storms and by the alternations of winter and summer; but Forbes in 1842, and Tyndall in 1859, showed by definite and crucial observations and reasoning that this veined or ribboned structure results from the movement of the ice in its unequal onward flow, where it is subjected to great pressure, with shearing of the interlaminated blue and white ice.

English and American glacialists and physicists, in their studies and discussions of the motion of glaciers, have devoted most of their attention to the veined structure, to the crevasses, and to the regelation of the ice from a crevassed to a continuous mass. Forbes demonstrated that the differential movement together of the various lateral, central, bottom, and surface portions of a glacier is like the flow of a viscous body, and that the blue and white veining is dependent on the viscoid motion. Tyndall, impressed by the incompatibility of true viscosity with the formation of crevasses, taught that the ice yields to the force of gravitation by a constant and exceedingly minute fracturing throughout all its mass, attended with refreezing or regelation, which continually mends again the imperceptible fractures after an infinitesimal sliding of the broken surfaces one past the other whereby the seemingly viscous flow takes place.

German and French observers and theorists, including Hugi in 1843, and subsequently Grad and Dupré, Bertin, Klocke, Forel, and Hagenbach, have specially noticed and studied another very interesting and particularly characteristic feature of glacier ice, namely, its granular structure. Within the past few years the results of these investigations, in their bearing on the explanation of the motion of glaciers, have been brought to the attention of English-speaking glacialists by Sir Henry Howorth;* and last year an important paper on this subject, giving careful observations and drawings of the granular structure, and indicating its probable relation to the physical conditions of glacial flow, has been jointly published by Messrs. R. M. Deeley and George Fletcher.† The glacier granules originate with the consolidation of the *firn* or *névé* to form compact ice, and, though doubtless constantly undergoing changes, they continue recognizable, by proper optical examination, in all the mass of the glacier, through its vicissitudes of pressure, differential flow, veining, fracture, and regelation, to the end of their course far below the snow-line, after many years or even several centuries of very slow advance from near the mountain summits to the limit of the glaciers amid the forests, fields, and gardens of the valleys.

Purpose of this Paper.

In the present paper inquiry is made concerning the influence of the sedimentary stratification of the *firn* or *névé* to

*The Glacial Nightmare and the Flood, 1893, vol. II, pp. 528-532.

†Geological Magazine, IV, vol. II, pp. 152-162, with nine figures, April, 1895.

yield the veined structure of mountain glaciers and the admirable lamination of the frontal cliffs of the Greenland and Antarctic ice-sheets, reaching the conclusion that these features in both the valley and continental glaciers are due solely or principally to differential motion under pressure. The drawings by Deeley and Fletcher of glacier granulation are reproduced in plate II, and their explanation of the molecular conditions of flow and change of the granules is also reproduced in their own words. From these theoretic considerations of glacier motion, the reader is next asked to weigh certain other opinions concerning the erosion, transportation, and deposition of the glacial drift, the fluctuating stages of the oncoming, culmination, and wane of the Ice age, and especially the effect of the warm climate brought in its closing Champlain epoch.

Stratification of Successive Snowfalls.

In view of the demonstrative observations of Forbes and Tyndall on the origin of the veining of the Alpine glaciers, to be presently stated, we need not describe the undoubted, though probably mainly indistinct, stratification of the firn by its intermittent and seasonal additions of snow. No one has traversed any portion of the Antarctic ice-sheet, which perchance in its yawning crevasses may display the bedding of the recent snowfalls forming its surface. Referring to this condition of the firn covering the Greenland ice-sheet, and its possible relation to the well marked stratification of the vertical cliffs of its margin and outflowing glaciers, Prof. T. C. Chamberlin writes:*

Beyond serious question, the general stratification had its initial stages in the original snowfalls. Whenever encrustment intervened between one fall and another, a layer of more or less definiteness resulted. Whenever a succession of falls was followed by a period of encrustment, a more complex and massive layer was formed. The seasons doubtless developed annual subdivisions, and possibly, at intervals of a few years, unusual summer effects bound the deposits of a succession of years into a great stratum. It is the testimony of Lieutenant Peary and his associates that the surface of the ice-cap, under the action of the great windstorms, becomes marble-like in solidity and texture, as well as in color. At the same time the erosion of the wind develops sastrugi, which further differentiates the accumulating snow. In view

*Bulletin of the Geological Society of America, vol. VI, pp. 205, 206, Feb., 1895.

of these varied agencies of stratification, it is doubtful if we can look with any confidence for criteria by which the annual snowfall can be safely distinguished from that of other periods.

The original stratification could not have been very pronounced. Perhaps it was intensified somewhat during subsequent consolidation, but some new agency was necessary to produce the more definite partings and to introduce the layers of debris. This agency appears to have been a shearing movement between the layers.

Veined or Ribboned Structure.

Alternating blue and white ice laminæ approximately parallel with the steep rock walls of valley glaciers, curving thence convexly downward and forward across the glacier, and streaming outward longitudinally along the line of union of confluent glaciers in parallelism with the medial moraines, were first noticed by Brewster in 1814, and were well described by Guyot in 1838, but were independently rediscovered by Forbes in 1841. The latter observer, in his monumental work, "Travels through the Alps of Savoy," describes the development of the blue and white bands in nearly vertical planes, coinciding with differential upward shearing motion, where the ice within the space of a few hundred feet becomes recemented under much pressure at the base of a rapidly descending and exceedingly crevassed part of a glacier. He accordingly decides that this veined or ribbon-like structure "*is developed during the progress of the ice downwards*—is subject to the variations which its momentary conditions of constraint impress—and that it has not the slightest reference to the snow beds of the névé." Having determined by measurements that the motion of the central part of the glacier surpasses that of its sides, which are hindered by the friction of the rock walls, Forbes endeavored to illustrate the shearing movements to which he attributed the veining or banding, as follows:*

There must be a *solution of continuity* between the adjacent particles of ice to enable the middle to move faster than the sides. Imagine the surface of a glacier to be divided into a number of stripes parallel to its length, and adjoining but not cohering. If it be ascertained that each stripe nearer the centre moves faster than its neighbour nearer the side, the stripes will move past one another parallel to their length, the central stripes gaining upon the lateral ones. If we attempt to give such a varying motion to the parts of a flat stiff body, as a long sheet of pa-

*Op. cit., second edition, 1845, p. 178.

per, we cannot effect it without tearing the paper by rents parallel to its length, or the direction of movement. Now, such must be the case with a mass of ice which does not move with a uniform velocity in its transverse section, but where every line of particles has the velocity proper to its position in the ice-stream. The ice will, therefore, be rent by innumerable fissures whose general direction will be parallel to its motion, and these fissures, becoming filled with water and ultimately frozen, will produce the appearance of bands traversing the general mass of the ice having a different texture.

In his later writings Forbes renounced the idea of the infiltration and freezing of water along the planes of shearing, which produces, indeed, only such exceedingly narrow and discontinuous fissures that the whole mass is quite as impervious as portions of the glacier lacking this structure. Nor is the delicately veined ice readily cleavable, until in its melting the white laminæ, which contain plentiful minute air bubbles, yield more quickly and are affected to a greater depth than the compact blue ice.

Tyndall especially attributed the veined structure to pressure and insisted on its close analogy with the slaty cleavage of rocks. Moving laterally and spreading out at right angles from the direction of greatest pressure, the particles composing the white ice laminæ receive nearly all the air which before was uniformly distributed through all the mass, while the blue laminæ endure the compression with little differential or shearing movement. The origin of the veining in a crevassed and recemented ice cascade or fall of a branch of the lower glacier of the Grindelwald is described by Tyndall, from his observations in 1858, as follows:*

On the middle of the fall itself no trace of the structure was manifest; but where the glacier changed its inclination at the bottom, being bent upwards so as to throw its surface into a state of intense longitudinal compression, the blue veins first made their appearance. The base of the fall was a true *structure mill*, where the transverse veins were manufactured, being afterwards sent forward, giving a character to portions of the glacier which had no share in their formation...... What has been stated regarding the Grindelwald ice-fall is true of that of the Rhone: the base of the cascade is *the manufactory of the structure*; and, as all the ice has to pass through this mill, the entire mass of the glacier from the base of the fall downwards is beautifully laminated.

According to the place and manner of origin of the blue and white lamination, Tyndall noted three distinctions: first, mar-

*Hours of Exercise in the Alps, 1871, pp. 369-371.

ginal veins, extending along the sides and turning forward into the central part of the glacier, developed by pressure due to the faster motion of the center; second, longitudinal veins, produced by mutual pressure between tributary glaciers; and third, transverse veins, resulting from pressure due to the change of inclination, and to the longitudinal thrust endured by the glacier, at the base of an ice-fall. In all these methods of its production, the ice lamination, like slaty cleavage and schistose foliation, arises from a shearing motion or reärrangement of the ice particles or molecules upon each other in some way which, through all the elaborate studies of Forbes and Tyndall, eluded their discovery. They each refer incidentally to the granulation of glacier ice, but seem to have given no attention to it as a possible key to the mysteries of the glacial lamination and flow.

Granular Structure.

F. Klocke,* summing up the results of his own and others' observations, states that glacier ice is a granular aggregate of ice crystals, in the same way as marble is such an aggregate of calcite crystals. The optical axes of the separate crystalline grains usually have no order, but the utmost irregularity, in their orientation; and the diameter of the grains varies, according to Klocke, from one to ten centimeters (from two-fifths of an inch to four inches). In the Aletsch glacier Forel observed that some of the ice grains become two to three inches in diameter. Drygalski, in Greenland, finds their maximum growth like the size of walnuts.

How the snow crystals of the firn are transformed into the glacier grains is not yet definitely traced. Deeley and Fletcher examined the ice beneath the firn snow (névé) near the summit of Mont Blanc, of which they write:†

The fragments of this ice were formed of the usual glacier grains, many of considerable size. On the average they were, as near as can be remembered, as large as peas or even beans. Indeed, in many instances where the névé was examined the ice was coarsely granular. Regarded from a distance the névé appears to be very finely stratified, layers of comparatively pure blue ice alternating with white ones. On close examination this stratified appearance is seen to be practically wholly due to the distribution in layers of countless imprisoned air-

*Neues Jahrbuch, 1881, Band I, pp. 23-30, written Nov., 1879, and Aug. 1880.

†Geol. Magazine, IV, vol. II, pp. 153, 154, April, 1895.

bubbles.... After a fall of snow, surface melting leads to the production of a mass of more or less spherical granules of ice, the interstices between which are occupied by air. Further accumulations of snow lead to pressure, the granules are compressed, and much of the air may be expelled. But under certain conditions of weather a surface layer of snow may be melted, and, freezing again, may form an impervious layer, and the adjacent air-bubbles be unable to escape, even under the pressure resulting from further falls of snow. Thus we have bands of air-bubbles parallel with the surface and alternating with strata of blue ice which are comparatively free from air....The small granular particles of ice referred to undergo a rapid metamorphosis. They grow, some of them increasing in size at the expense of others, until they may exceed one or two inches in diameter, and would probably increase indefinitely but for the stresses existing in the glacier which cause their fracture. The mode of growth, and also the effects of fracturing, are discussed later. It is remarkable that these changes in the shape and size of the ice-grains do not appear to affect the arrangement of the air-bubbles, the layers of which are extremely regular, the transference of water in a molecular condition from grain to grain failing to affect the position, in space, of the air-bubbles, which are seen to traverse the crystalline grains.

Seven figures of the glacier grains, drawn as seen in thin slices with a polariscope by these authors, which they present in the paper cited, are reproduced on a somewhat smaller scale in Plate II. Figure 1 exhibits the striations on the surface of ice crystals in the ice-cave of the Rhone glacier. Here the largest crystals are nearly two inches long. Figure 2 shows the granular structure of the ice in the grotto at the foot of the Obergrindelwald glacier. The section is vertical and at right angles to the direction of flow. Attention is directed to it as revealing a lamination which on weathering produces blue and white veins. It also well displays the remarkable difference in size of contiguous grains. Figure 3 is a section in the ice-cave of the Rhone glacier, taken in a vertical plane parallel with the flow. As in the preceding figure, it is seen that most of the grains have a greater horizontal than vertical extension, and that they are roughly arranged in layers with approximately horizontal shear planes. "In many cases," say the authors, "where the shear planes are best marked the grains are smallest. Indeed, we have layers an inch or more thick, in which the crystals are large as in Figure 6, and the bounding surfaces utterly irregular. Between them are layers composed of smaller

FIG. 1. SCALE 5/12.

FIG. 2. SCALE 4/9.

FIG. 3. SCALE 2/3.

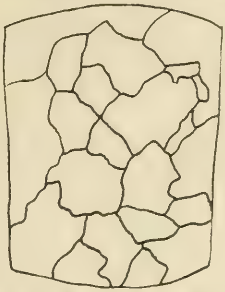


FIG. 4. SCALE 2/3.

FIG. 5. SCALE 2/3.

FIG. 6. SCALE 2/3.

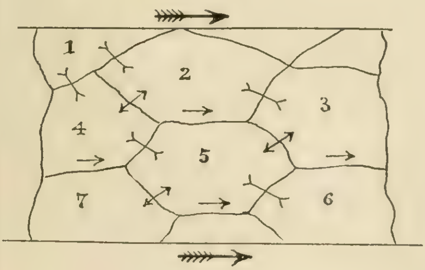


FIG. 8.

FIG. 7. SCALE 2/3.

GRANULATION OF GLACIER ICE.

(AFTER DEELEY AND FLETCHER.)

crystals with more or less clearly defined shear planes. Here the grains have been broken by excessive strains."

Figures 4 and 5 show horizontal slices of the Obergrindelwald glacier, parallel with the veined structure. Figure 6 is a horizontal section from the Eismeer of the Untergrindelwald glacier, taken from beneath the medial moraine. There the ice had a clear blue color, with no observable veining. Lastly, figure 7 is a vertical section from the Mer de Glace, with lines of shear planes, showing again very conspicuously how far even adjacent grains vary in size.

Concerning Tyndall's reference of the vein structure or lamination primarily to pressure more than to differential shearing motion, with corresponding modification of the granular structure as shown in the figures, these authors remark: "In all cases, as far as our experience goes, the direction of the veined structure, rather than being at right angles to the direction of greatest pressure, was such as would be produced by the *shear* the glacier undergoes in changing its shape, or rather the relative position of its parts, during its descent."

Ice frozen on the surface of a lake or river differs entirely from the granular ice of glaciers in having a prismatic structure, so that often by slow melting during the spring, with accompanying rains, it is divided into columns which only loosely cohere together. Gen. J. G. Totten described a most surprising instance of the rapid disappearance of the ice, about a foot thick, from lake Champlain during a single windy night, owing to this method of melting. The ice, he says, was "a mere aggregation of vertical prismatic crystals, cohering only at points and along edges and narrow surfaces. as shown next morning by fragments on the shore."*

The granular structure is, therefore, a decisive proof that the underground ice strata found by Baron Toll in the New Siberia islands, and the similar ice formation of Eschscholtz bay and other localities in northwestern Alaska, compared by Dall to compacted hail as its peculiar texture is disclosed in melting, are, as Toll has well named them, "dead and fossil glaciers."†

*Am. Jour. Sci., II, vol. XXVIII, pp. 359-364, Nov., 1859.

†See the Am. Geologist, vol. XV, p. 258, April, 1895; vol. XVI, pp. 314-316, Nov., 1895.

Flow of Glacial Molecules and Grains.

Through all the patient observations and laborious theorizing of physicists concerning the methods of the flow of glacier ice, an ever increasing knowledge of the physical conditions and laws of glacial flow is manifest. As Tyndall has generously said, De Saussure, the pioneer of alpinists, doubtless knew the viscoid action of the glaciers in sweeping around the promontories and islands of their pathways. Scheuchzer and Charpentier seized something of the truth, or a close analogy of it, in attributing the ice flow to infiltering and freezing water. Rendu, without experimental proof, affirmed the river-like faster flow of the central ice; and Agassiz and Forbes, working independently, demonstrated this within the next year by measurements. Faraday and Tyndall, in their studies of regelation, carried the physical theory a step beyond Forbes; later, Moseley placed a useful emphasis on the influences of seasonal and diurnal changes of temperature; and lastly Croll, in his molecular theory, almost grasped the recently published doctrine which is based on the granulation.

Figure 8 on plate II illustrates this view of Deeley and Fletcher, concerning the changes of form which the glacier granules undergo, one being diminished and its fellow increased, in yielding to the pressure of gravitation and shearing motion, by which, in a way quite analogous to the flow of a viscous body, the glacier moves down its valley. They write as follows:*

While a mass of Glacier-Ice is viscous in all directions, it has been found that a single crystal of ice is only viscous in a direction at right angles to the optic axis. A single crystal, or a portion of a crystal, will yield to continuous transverse stress applied in a direction parallel to the optic axis, but will not yield in a direction at right angles to the axis—in brief, viscous shear may take place in one plane only. Now, if all the crystalline grains constituting a glacier had their optic axes arranged parallel with the direction of motion, or if there were a large majority of grains so arranged, it would not be difficult to account for the mode of motion of a glacier; but there is not any such relation between the optical structure of the glacier grains and the direction of motion. If we imagine shear to take place in any single grain, the motion will be stopped by adjacent crystals exhibiting rigidity in that plane. Indeed, it does not appear that a glacier in moving can make any use of the fact that ice-grains are viscous in one plane, for the direction of that plane varies in almost every grain. How, then, does the glacier move? Why does it, as a whole, exhibit viscosity?

*Loc. cit., pp. 160, 161.

When a plastic or viscous substance undergoes change of form without change of bulk, the distortion in its simplest form may be regarded as due to the formation of great numbers of parallel shear planes. In such a case every molecule of each plane must change its position with respect to every other layer of molecules. On the other hand, if the substance be built up of a number of rigid grains of all shapes and sizes, closely fitting and adhering to each other, the nature of the change necessary to give rise to distortion is much less simple. In such a case not only do we require shearing between the interfaces of the particles but also a change of shape of the particles themselves. And this must go on in ice without producing more than local ruptures. for its tenacity and shearability are sufficiently high to resist general fracture. To account for Glacier-Motion, therefore, we have to show that the glacier grains can not only increase in size but also change their shapes under the smallest stresses, and also that they can, under similar conditions, slide over each other without actual fractures resulting.

We will first consider the question of change of shape and size. Fig. 8 shows an ideal case of a number of particles lying between two parallel planes, the upper of which is moving more rapidly than the lower one. The small arrows near to or crossing the interfaces indicate the direction in which shear must take place, and also show those surfaces which, being pressed together, must be wasting, and those surfaces which, being in tension, must be growing. Although we shall deal with the case as though each crystal had rectilinear motion only, it must be remembered that they will have a tendency to roll over each other as well. This, however, rather reduces than adds to the difficulty of the problem, as does also the viscosity of ice-grains along planes at right angles to the optic axis. We have seen that a very large number of the molecules at the interfaces of the crystals are free; that is, they sometimes form portions of one crystalline structure, and sometimes of another. Probably within a few minutes all the surface molecules have been free, and have, therefore, been at liberty to assume positions more in accordance with the conditions of stress and strain in the mass. For instance, the conditions of stress will be different for each of the faces separating the three crystals, 2, 4, and 5 of Figure 8. One is in compression, the other in tension, and the third in shear, and consequently the structure between 4 and 2 is more open (being in tension) than that between 4 and 5, the adjacent faces of which are in compression. Under such circumstances, it is reasonable to suppose that there would be a migration of molecules from the opposed faces of 4 and 5 to the opposed faces of 4 and 2. An exceedingly slow change of this kind would be sufficient for our purpose. There now remain the faces, such as those between 2 and 5, to consider. In these the case is one of simple shear.

This explanation, which may perhaps properly be called a Granulation Theory of glacier motion, appears more nearly allied to the view of Forbes than to that of Tyndall. Yet, if it be, as it seems to me, an expression of the physical conditions by virtue of which glaciers act as if they were viscous or plastic, ice after all has truly neither quality; nor is it fractured or bruised along innumerable infinitesimal planes throughout its mass, and again reunited by regelation. The heat of summer, and of unusually warm weeks or days, by quickening the interplay of the molecules forming the surface of the ice grains, so that one increases and another decreases more rapidly, is an important element to greatly augment the motion of the glacier; but in the coldest winter the reduction of the temperature is only a small fraction of the whole range downward to the absolute zero or absence of heat. The suggestive studies of Henry Moseley and James Croll, having special reference to temperature, are apparently superseded; but in their time they were needful contributions toward the attainment of this latest, and to my mind most intelligible, theory of physical processes which are clearly and unmistakably seen, but which have so long baffled the most learned and eager investigators.

LAMINATION DUE TO DIFFERENTIAL FLOW.

After consideration of this Granulation Theory of the motion of glaciers and ice-sheets, I believe that the conspicuous stratification of the vast tabular icebergs discharged from the Antarctic ice-sheet, as observed by H. N. Moseley during the cruise of the Challenger,* the veined structure or lamination reported by Russell in the still existing glaciers of the High Sierra,† the lamination, sigmoid folding, and faulting, seen by Hamberg in Loven's glacier, Spitzbergen,‡ the very interesting similarly stratified, folded, and faulted ice layers, with much englacial drift, described by Chamberlin as forming the frontal cliffs of glaciers and of the margin of the Greenland ice-sheet in the region of Inglefield gulf,§ and the fine lamination of the glacier ice seen by Deeley and Fletcher beneath the firn of Mont Blanc, all are due not to deposition of successive snowfalls, becoming so clearly defined in these

*Notes by a Naturalist on H. M. S. Challenger, 1872-1876, chapter x.

†U. S. Geol. Survey, Fifth Annual Report, for 1883-84, pp. 318, 319.

‡AM. GEOLOGIST, vol. XVI, p. 200, Sept., 1895.

§Bulletin of the Geol. Society of America, vol. VI, pp. 199-220, with eight plates, Feb., 1895; and a series of illustrated papers in the Journal of Geology, vols. II and III, for Oct.-Nov., 1894, and onward.

beautifully laminated ice strata, but to the flow of the ice fields under the pressure of the overlying ice and firn. The superincumbent weight in all these examples of the production of glacier lamination may have been equal, at least, to the weight with which the Alpine glaciers are pressed in passing the bends and constrictions of their valleys or at the base of their steep and crevassed frozen cascades.

Relation to Drift Erosion, Transportation, and Deposition.

With the general onward current of the glacier, there is probably, as the writer thinks, a component of motion by drag from the friction-hindered ice of the valley sides toward the freer flowing center, as indicated by the courses both of the marginal crevasses, trending up stream into the glacier, and of the shear planes of blue and white veining, which trend across the crevasses and pass down stream into the swifter central current. The arched cross section, however, forbids the marginal moraines from being swept away from the sides; and this part of the lateral motion, most important close to the rock walls of the valley, is not traceable far out into the glacier, which there receives abundant inflow from the main descending ice current.

Similarly the bed of the glacier, in being worn away by the rasping boulders, gravel, and sand frozen in the bottom of the ice, has glacial currents which, by the drag of the freer flowing higher part of the ice stream, are borne gradually up from the rock or drift upon which the glacier lies, carrying their drift along shear planes and in the general body of the ice to hights that I have elsewhere estimated to be a quarter or a third of the whole thickness of the glacier or ice-sheet. In regions now receiving abundant snowfall, as Greenland and the Antarctic continent, little ablation takes place on the border of the outflowing ice, and its englacial drift there maintains nearly the same ratio of its altitude, in comparison with the whole thickness of the ice, as in the much deeper part, where also the englacial drift doubtless reaches far higher, at distances from 50 to 200 miles or more back from the boundary. But in a region like Alaska, having less snow than formerly and consequent gradual decrease of the ice borders by ablation, much englacial drift becomes superglacial, covering the attenuated ice margin.

The "dirt bands" of the Alpine glaciers, and of the Sierra Nevada glaciers as observed by Russell, are probably due to such transfer of englacial drift from the glacier bed to hights where it becomes exposed by the ablation of the part of the glacier below the snow-line.

These opinions need not here be more fully discussed or supported by the evidence which seems to me to be afforded by our Pleistocene glacial drift for the action of the ancient North American ice-sheet in the ways thus indicated. All that the writer here desires is to call the attention of glacialists to his former papers on the englacial drift,* and to ask that his views receive the added light which this Granulation Theory of the ice motion may contribute.

When the ice-sheet of this continent attained its greatest extent, erosion probably was in progress on all the ice-covered country, excepting near its limits, being most rapid within some such distances as from 100 miles to 200 or 300 miles inside the ice border. Deposition prevailed, we may infer, on a somewhat broader peripheral belt than during the ensuing time of disappearance of the ice-sheet, which was attended by the recession of this belt of deposition, estimated to have been then 20 to 50 miles wide, across all the previously eroded country. The englacial drift supplied by the wide and long continued erosion, is supposed, according to my studies of the drift formations, to have been then laid down in great part, apparently more than half of it all, as the ground moraine of subglacial till; and the remainder, which continued to be englacial or superglacial until the ice was wholly melted, is thought to have formed the retreatal moraines, kames, and eskers, and the valley drift in its varieties of gravel, sand, clay, and loess.

Effects of the Warm Champlain Climate.

During the time of accumulation and culmination of the ice-sheets, we have proofs, in the depths of fjords and submarine continuations of river valleys, that their areas in both North America and Europe were raised 1,000 to 4,000 feet or more above their present altitude. To the continuously cool

*Bulletin, Geol. Society of America, vol. III, 1892, pp. 134-148; vol. V, 1894, pp. 71-86. Am. Geologist, vol. VIII, pp. 376-385, Dec., 1891; vol. X, pp. 339-362, Dec., 1892; vol. XII, pp. 36-43, July, 1893.

and snowy climate so induced the growth of the ice-sheets to their demonstrated thickness of a mile or more is attributable. The time of accumulation and extension of the ice was doubtless long, in comparison with its generally rapid final melting, which is known from many features of the drift deposits of that time. Instead of the preglacial high altitude, both these continents stood at nearly their present hight, or in the drift-bearing portions mostly 100 to 500 feet lower than now, when the ice melted away; and this closing or Champlain epoch of the Ice age seems to have depended on the subsidence of the land from its previous great hight.

Not only were the borders of the ice-sheet thus rapidly melted back, giving an increased steepness of the frontal slope and faster glacial flow, as compared with the time of maximum glaciation; but also the influence of the warm climate properly belonging to the low altitude, apparently having nearly as high mean annual temperature as now on the same latitude, further reinforced the vigor of the ice currents by the facility of molecular change of the ice grains and flow of the whole mass toward its waning boundary. The rapid accumulation of the moraines, even those of largest size requiring probably only a few decades of years, is readily accounted for by the double effects of the steeper gradients and the warm temperate climate. We are enabled to see how the fast flow of the Arctic glaciers terminating in the sea is consistent with very slow movement of the ice border on contiguous high land; and why the sluggish ice action of the time of farthest glacial advance was followed by the energetic moraine-forming glacial currents of the Champlain epoch, that is, the time of subsidence of the land and final recession of the ice.

FLOATING SAND: AN UNUSUAL MODE OF RIVER TRANSPORTATION.

By Frederic W. Simonds, Austin, Texas.

On the eighth day of August last I joined a camping party at Bessemer, on the Austin and North Western railway, 93.75 miles from Austin, in Llano county, Texas. This station is on the Llano river, a clear stream, tributary to the Colorado, flowing through what has been termed "the Central Mineral region." Inasmuch as the rocks bordering the river are, for the most part, Archean granites, both red and gray, schists, etc., the sand resulting from their disintegration may with propriety be termed "granite sand," even though composed largely of vitreous and pink quartz with only subordinate quantities of feldspar, biotite, and accessory minerals.

The morning after my arrival the river was found to be rising and, as I stood on the bank, at the point where we secured our water supply, I noticed a considerable froth and, what appeared to me at the time, scum passing down the stream. I spoke of the condition of the river to my companion, Mr. Laurence D. Brooks, of Austin, who remarked that what seemed to be scum was really sand. I thereupon went down to the water's edge and, dipping up some of the floating material, was astonished to find that the patches were composed of sand, mainly of quartz. At this time, half-past nine or ten, the water supported a large number of patches, which varied in area from less than a square inch up to several square inches, all swept along by the current.

This phenomenon was witnessed only while the river was rising. When the water began to recede no more floating sand was seen. The reason for this will appear later.

Noting my surprise, Mr. Brooks stated that he had seen sand floating on some of the streams of Alabama, and that it had oftentimes been very troublesome in digging water-holes. To test this statement I at once scooped out some holes in the damp sand and, surely enough, as their sides caved in, a few grains floated away on the surface of the water which immediately filled the holes. Between the grains there seemed to exist a mutual attraction in consequence of which they ultimately grouped themselves into small patches similar to the smaller patches seen on the river. In the meantime, Mr. Brooks, by gently sifting dry sand from his hands onto the water, succeeded in forming much larger patches.

A week later, when the river was well down and the sandy stretches of its bed had become quite dry on their surface, I gathered sand by the handfuls and sent it floating down the stream in such quantities that the sand-rafts actually cast shadows on the bottom as they passed. Then I dug several large holes, as I had previously done in the damp sand, but with far better results, for, when their sides caved in, the dry grains forming the outer coat of the deposit, were gently launched and floated off much more abundantly. Futhermore, as each mass of sand slipped into the water and, exclusive of the floating grains, sunk, the air contained in the interstices between the particles rose to the surface forming a patch of foam or froth. The observations here made afforded strong proof of the probable explanation of the phenomenon of floating sand from a geological standpoint, the physical explanation being quite a different matter.

The bed of the river above Bessemer contains much sand and as the water rose, at the time mentioned, not from the occurrence of local rains, but from those at a distance, the edges of the sandy stretches bordering the flowing water must have slowly caved in, thus launching the dry sand which floated away forming patches through the mutual attraction of the grains, while the damper masses, sinking to the bottom, contributed foam from the entangled air.

The only mention of floating sand at present known to me is that by Mr. James C. Graham in a brief article "On a peculiar method of sand-transportation by rivers," published in the American Journal of Science, III, vol. XL, p. 476, Dec., 1890. The phenomenon was observed on the Connecticut river and is described as "a case of the transportation of siliceous sand upon the surface of the water, due to capillary floating." The sand in question was removed from a bar jutting out from an island. "The erosion was being carried on from the side of the bar against which the current did not strike. It took place by gentle ripple waves splashing up against the sand bar (which was at an angle of about 150° to the surface of the water) and upon the retiring of each wave a little float of sand would be on the water. At first these were about the size of a silver quarter of a dollar, but by the union of a number, some floats would be formed of about six inches square." The floating patches thus described by Mr. Graham are quite like those observed by me on the Llano river.

After I had read the above account I again (September 7th) visited the river near Bessemer and was more than ever convinced that the explanation I have offered as to the manner in which the sand grains are launched is, for that locality, correct. I found places where the running water had cut down into the sand leaving overhanging cliffs, in miniature, varying from 3 to 6 or more inches in hight. By pressure I forced a portion of this border farther outward and, as the current completed the undermining, the mass slid into the water which bore away many of the dry grains on its surface. Combining Mr. Graham's observations with my own, it would appear that dry sand may be naturally floated in at least two very different ways, viz.: First, by gentle ripple waves splashing up against a sand bar having an inclination of about 30°, as on the Connecticut river, and second, by the undermining of the sand beds bordering portions of a stream, as on the Llano river.

Though, as I have stated, the Llano sand was derived chiefly from the disintegration of granitic rocks, it effervesces slightly with dilute hydrochloric acid. This, however, is not surprising when it is known that metamorphic limestones also occur in this region. That granite fragments will float, and in a manner quite similar to this sand, I have demonstrated by breaking some red (Burnet or Capitol) granite in an iron mortar, until it had been reduced to a corresponding degree of fineness, and then gently sprinkling it from a paper onto the surface of the water. As might have been expected, much of it immediately sunk, but a sufficient quantity floated away to form a characteristic patch. Milky quartz when treated in a similar manner yielded even better results, as did orthoclase also.

That the property of floating is by no means confined to the sand of any one locality or to that of any particular origin may be seen from an inspection of the accompanying table.

How long sand will float, granting that the size and shape of the component grains admit of floating at all, I cannot say, but, should the surface of the water remain unbroken, I believe for an indefinite period. I base my conclusion on the following facts: In my laboratory I have floated sand in various vessels for hours. In one instance, for the sake of the test, I allowed the water, with its sand, to remain for more than a month undisturbed. At the end of that time, as

NO.	LOCALITY.	ORIGIN.	COMPOSITION.	SIZE AND SHAPE OF GRAINS.	BEHAVIOR OF GRAINS.
1.	Coast of Long Island.	Unknown.	Mainly quartz, milky and vitreous.	Fine and very angular.	Nearly all float.
2. *	Medina, N. Y.	Medina sandstone.	Quartz.	Various.	Form patches on water; floating grains; angular.
3. *	Near Union Springs, N. Y.	Oriskany sandstone.	Quartz; milky and vitreous.	Coarse; mainly angular.	Very buoyant; but few sink.
4. *	Pea Ridge, Ark.	Lower Carboniferous sandstone.	Ferruginous and vitreous quartz.	Fine; very angular.	Nearly all float.
5. *	Alum Bay, Isle of Wight.	Variegated sandstone.	Quartz.	Very fine; angular.	Form a characteristic patch; must be launched with care.
6. **	Red River, Greer Co., Texas.	Granite.	Quartz.	Rather fine; both angular and rounded.	Small proportion floats, apparently the more angular grains.
7. **	Wise county, Texas.	Trinity Cretaceous.	White, pink and vitreous quartz.	Coarse and fine intermixed; edges of the larger grains rounded.	Nearly all sink.
8. **	Double Mountain, Stonewall Co., Tex.	Trinity Cretaceous.	Quartz.	Very fine; angular and rounded commingled.	With care a floating patch may be formed.
9. **	12 miles S. E. of Baird, Callahan Co., Texas.	Basal sands, Cretaceous.	Quartz.	Very fine; edges mostly rounded.	Very few float; many held in suspension.
10. **	Taylor county, Texas.	Water-bearing Trinity sand, Cretaceous.	Quartz.	Very fine.	Very few float; the more angular.
11. **	Near Dublin, Erath Co., Texas.	Upper Trinity sand.	Quartz.	Fine and rounded; few angular.	Only a few, the more angular, float.
12. **	Iron Mountain, Gould P. O., Rusk Co., Tex.	White Tertiary sand.	Quartz.	Fine, angular.	A large proportion floats.
13.	Austin, Texas, Colorado river.	Central Mineral region in part.	Quartz, milky, vitreous, ferruginous.	Rather coarse; both rounded and angular.	A small proportion floats; mainly angular or flattened grains.
14.	Chicago, Ill., Lake Michigan.	Unknown.	Composite; vitreous quartz, calcite, fragments of sandstone, etc.	Fine; mostly angular.	Very buoyant.

* Obtained from fragments of sandstone.

** From the museum of the Texas Geological Survey, by courtesy of Mr. E. T. Dumble.

might have been anticipated, owing to the evaporation of the water, many of the grains had become stranded on the sides of the vessel, yet quite a number were still floating.

How far sand will float is another question difficult to answer. Mr. Graham records his observations on the Connecticut river sands as follows: "These blotches were so numerous as to be very noticeable in rowing up the river and could be traced for half a mile or more below the bank, though this bank from which the sand came was but a few yards long."* I have not followed the Llano river rafts for so great a distance, though I have, with difficulty, traced them along the bank on several occasions—once for more than a hundred yards, when by the rippling of the current and the reflections of small waves caused by a slight breeze, they were lost to view. If the liquid is agitated to such an extent as to break the surface and to wet completely the floating grains much of the sand will drop to the bottom, though I have found that in a small vessel some grains have remained floating after a considerable stirring with a glass rod and after repeated shaking or jarring. At a point, where a portion of the river had separated from the main stream and the water flowed quite rapidly, I started several series of rafts. As the velocity of the current increased and the ripples became stronger the adhesion between the grains weakened until the rafts, as such, disappeared, though individual particles continued to be seen for some distance farther. Such being the case we may expect that whenever a stream passes over any irregularity in its channel, such as rapids, even if very small, or waterfalls, the floating sand will sink, indeed such a result may be looked for when the surface is disturbed by a wind.

Before proceeding further, I wish to say that the Llano river sand is not an extremely fine sand, but, on the contrary, rather coarse. The grains are not, however, of uniform size. While some are small, many are comparatively large. The following measurements of four selected quartz grains will serve to indicate, approximately, the size of those that float:

*Loc. cit.

	Greatest length.	Greatest breadth.	Thickness.	Weight.
1. Pink quartz	5 mm.	3.5 mm.	1 mm.	.0231 grms.
2. " "	4 "	3 "	1 "	.0141 "
3. White quartz	4 "	4 "	3 "	.0304 "
4. " "	5 "	3.5 "	2 "	.0179 "

The specific gravity of each of the ingredients of "granite sand" of course exceeds that of water, that of quartz being 2.5-2.8; of feldspar 2.44-2.62; of biotite 2.7-3.1. If these ingredients were present in the same proportions their average specific gravity, i. e. the specific gravity of the sand, would be 2.54-2.84, or, say, 2.69. The specific gravity of that part of the sand under investigation which had actually floated was found to be 2.59.

The attempt to explain the phenomenon, or possibly I should say phenomena, of floating sand from a physical standpoint involves the investigator in difficulty, so what I have to offer is tentatively given with the hope that as physical research advances the subject may become better understood.

When shaded, it will be seen that the floating sand grains cause a depression of the water's surface, which, indeed, is quite as apparent in the case of isolated grains as in that of patches. I recall one instance where the depression, though of very short duration, possibly but a few seconds, was so great as to be positively startling. As I was sprinkling some sand upon the river, for experimental purposes, a pebble almost as large as the end of my little finger fell into the center of a floating patch, which, to my great astonishment and delight, was depressed, like a funnel, for, say, half an inch before the cause of this unexpected phenomenon broke through its surface and sunk to the bottom.

It appears from these and other observations that the weight of the sand grains actually depresses the surface of the water, yet the elastic reaction of that surface is sufficiently great to prevent them from sinking, especially when the resistance offered by their angularity is taken into consideration. In the launching of grains the more rounded would tend to roll over in the water and thus become wet in consequence of which they would sink, while those of an irregular shape would overcome the tendency to roll and remain partially dry, thus fulfilling a condition necessary for floating. That the angularity of the grains is conducive to the floating of the sand is shown in the first table given.

All my experiments heretofore having been made with water from either the Llano or Colorado rivers, it occurred to me that possibly a difference might be noticed in the surface reaction should other water be employed. I accordingly repeated several of my tests using rainwater, Colorado river water, boiled and filtered, and distilled water with little or no appreciable difference in the results.

The second part of the phenomenon, or, as I am inclined to regard it, the second phenomenon, is the formation of patches or rafts from the floating grains. Here the investigator encounters another difficult, yet interesting, problem in capillarity, viz.: The attraction, though largely apparent, existing between small bodies floating on a liquid. Leaving gravitation out of consideration the usual explanation offered is as follows: The floating sand grains are not wet by the water and when brought sufficiently near one another the depressions, in which they rest, unite thus leaving between them an interval in which the water is below the general surface, hence by the pressure of the surrounding liquid they are urged together.*

It seems to me, however, that the so-called attraction between the individual sand grains, as shown in the formation of rafts, is exerted over a greater distance than could be accounted for in the explanation above given. Thus I find that on an undisturbed surface of water they are brought together when separated by an interval as great as 4 cm., and that when scattered over the surface of a basin of water a foot in diameter they will finally form a single raft.

The observations made by Mr. Graham on the Connecticut river enabled him to reach the following conclusions:

1. They show that coarse sand can be floated away on a current of far less velocity than 0.4545 miles per hour.

2. They show a method of removing sand from the lower side of a forming bar which has gotten above high water mark.

*For another and ingenious explanation see the paper by the late professor John LeConte on "Apparent attractions and repulsions of small floating bodies." Amer. Jour. Sc., III, vol. XXIV, p. 416, Dec. 1882.

3. They indicate a possible explanation of the coarse particles of sand found in otherwise very fine deposits.*

My own observations and experiments confirm conclusions 1 and 3. I find, in addition:

1. That sand grains will float in perfectly still water for an indefinite time.

2. That the grains which float are not necessarily siliceous. That flakes of mica, fragments of marble, bituminous shale, etc., also float and that some of them, the marble and the bituminous shale, for example, are unusually buoyant.

3. That the property of floating is not confined to the sand of any particular locality but depends to a considerable extent upon the angularity, i. e. the shape of the grains.

4. That whether sand will float or not depends, also, upon the mode of launching. Whether it be by ripple waves, as stated by Mr. Graham, or by under-mining, it must be gently done, for should the grains be plunged into the water with sufficient force to completely immerse them they will immediately sink.

5. That the natural conditions necessary to the floating of sand in rivers are somewhat unusual, depending, in the case of the Llano, upon a flood without local rains and, in that of the Connecticut, upon the manner in which certain waves strike a sand-bar. It is quite possible, however, that floating sand is much more common than is ordinarily supposed.

6. That the physical explanation of the problem is complex rather than simple, and at best unsatisfactory in several important particulars, and that with the advance of molecular physics we may hope for a better understanding of what we now, for convenience, term "superficial viscosity" and "capillary attraction."

School of Geology, University of Texas, Nov., 1895.

ANCIENT RIVER DEPOSITS OF THE SPRING RIVER VALLEY IN KANSAS.

By Oscar H. Hershey, Freeport, Ill.

In the February (1895) number of the Am. Geologist, Mr. Arthur Winslow mentions certain gravel deposits along Spring

*Amer. Jour. Sc., III, vol. xl, p. 476.

river in southwestern Missouri, and considers them of Tertiary age. I have examined the region, although in a rather desultory manner, and perhaps my observations may contribute some light on the subject.

Between the towns of Galena and Baxter Springs in Cherokee county, Kansas, the K. C., F. S. & G. railroad crosses the Spring river near the small town of Lowell. Here the valley was found to consist mostly of a nearly level plain, bounded on the east side by abrupt bluffs of Lower Carboniferous limestones and on the west by gently sloping hills of Carboniferous shales and sandstones. The valley plain varies from one to several miles in width and stands 50 or 60 feet above the ordinary level of Spring river. It constitutes a "second bottom" of that stream. Railway cuttings and excavations by the stream in its banks show this terrace to be composed mostly of solid rock overlaid by a brownish red gravelly clay, showing unmistakable signs of deposition in water. This gravelly clay is a river deposit formed by Spring river at a time when it flowed at a higher level, meandering over the broad plain which now forms its "second bottom." It is synchronous with similar terrace gravels found throughout the Ozarks, which latter I correlate with the Lafayette formation in the lower Mississippi region. Hence its age may be placed near the end of the Tertiary era.

At the close of the Pliocene period and opening of the Pleistocene, when the eastern portion of North America was elevated to a high altitude, the region about Spring river participated to a certain extent in this movement, and the stream trenched its present comparatively narrow trough to a depth of at least 50 to 60 feet below the former flood-plain. This new valley does not exceed in size more than one-twelfth of the upper trough of Tertiary erosion, and where it has been excavated in very hard strata it is much smaller.

In comparatively recent times the valley of Spring river and the surrounding region were greatly depressed below their present level. This caused a flooding of the stream, resulting first in the formation of a bed of clean, perfectly waterworn, and finely stratified gravel and sand. This deposit is confined to the sides of the newer or Quaternary trough, and outcrops in the river bank along the edge of the terrace lands. It was formed soon after the flooding had begun. But as the subsidence continued a fine silty deposit resembling *loess* was laid down over the gravel, reaching also to a higher level in the valley. Still later, when the subsidence of the land had reached its culmination, the waters spread out over the broad terrace or "second bottom" as a great lake-like stream with feeble currents, and deposited over the plain a few feet of light brown loam free from gravel. This now constitutes the surface, except where it has since been removed by erosion, the underlying gravelly clay being thus laid bare.

The land then rose to approximately its present altitude and erosion has continued at varying rates, but uninterrupted, to the present day. The stream has nearly cleared its lower trough from the gravel and clay, and has made some progress in excavating the solid rock of the terrace and bluffs. As the stream is at baselevel it is forming a narrow and low flood-plain of black sandy alluvium.

Lithologically, the brown loam or clay which overlies the terrace, resting on both the Lafayette gravel and the more modern river gravel in the lower trough, is an exact imitation of portions of the upper member of the Columbia deposits in the Ozarks and the lower Mississippi region, and of the Missouri loess and its correlative deposit in the Osage valley. But it is not true loess, as it contains no glacial *rock flour*. The amount of subaërial erosion effected on the surface of the loam since its deposition and by the stream in the same time fixes its age at or near the Columbia epoch. Furthermore, the epeirogenic movement which caused the rise in the stream to produce it may be definitely correlated with that which caused the deposition of the Columbia formation on the coastal plain, in the Mississippi embayment region, and about the borders of the Iowan ice-sheet. In short, there is much evidence that the deposit is of Columbia age.

I desire to call attention to the following points in the Quaternary history of this district:

1. The supposed Lafayette gravel and clay of the Spring River valley date from a time when the land stood at lower altitude than the present.

2. Next was a marked and to a certain extent permanent uplift of the region.

3. The post-Lafayette period of erosion exceeded the post-Columbia by at least the ratio of five to one.

4. The Columbia deposits in the Spring River valley indicate a gradual subsidence of the region, increased precipitation, decrease in average annual temperature, and a muddy condition of the waters.

5. Apparently the movements of the earth's surface were here greater in amount than farther east in the central portions of the Ozark region. They probably increased in intensity from some area in Arkansas northwestward to some area in the upper Missouri valley: and the Spring River region was also doubtless somewhat effected by movements in the Rocky Mountain region.

What has been here said in regard to the phenomena in the Spring River valley in Cherokee county, Kansas, applies with equal force to adjacent portions of Missouri and the Indian Territory. The Columbia deposits are well developed along Shoal creek and along Spring river and its main tributaries in Missouri. The red gravelly clay, which I consider the equivalent of the Lafayette formation, appears also along the streams in southwestern Missouri, and indeed in the valleys of the entire Ozark region; and Mr. Winslow is, I believe, correct in referring its deposition to Tertiary time.

THE TIMEPIECE OF GEOLOGY.

By E. W. Claypole, Akron, Ohio.

In the early days of geology superposition was the only test of age. As soon as clear ideas regarding the structure of the stratified rocks were attained and their general relations to the unstratified masses became known, it was an obvious deduction from this knowledge that the lower strata were the oldest and that the overlying ones had been laid down consecutively upon them. The distinction into Primary, Secondary and Tertiary soon arose, and of this early nomenclature some traces still survive. But the work of William Smith, the father of English geology, awakened a suspicion that these rocks contained in themselves evidence that might be used to determine their dates. This supposition rapidly became a certainty as collections increased and as their specimens were more and more closely studied. Paleontology was born. The dictum of Smith that fossils were not strewn indiscriminately amongst the strata was proved to be true, and the geological world awoke to the fact that if these fossils were known the rock from which they came might be inferred with certainty.

What coins and medals are to the numismatist and antiquarian, fossils now became to the geologist. They were found to carry on their faces the dates of their creation. Then followed in succession the belief in a long succession of fossil faunas reaching back, one behind another, into the distant ages of the past, to a remoteness that was startling by its antagonism to the current doctrines of the day. No idea of gradual transition had yet dawned. These faunas were looked upon as separate and independent. Each disappeared, if the thought on the subject had ever gone so far as this, in a world-wide catastrophe by the intervention of a *deus ex machina* to remove it and it was followed by a new one brought in by recreative energy to take its place. No ancestral connection was imagined to explain the succession. Elie de Beaumont's catastrophic geology was the geology of the time, and the story of life on this earth was a drama interrupted from time to time by the fall of the curtain and the shifting of the scenery.

Slowly the evolutionary idea of genetic connection between these varied faunas took shape, and instead of a series of disjointed views a continuous picture was presented. Local disaster or gradual change succeeded to universal catastrophe and the uniformitarian school, with Lyell at its head, came to the foreground. It is not possible to overestimate the value of the contribution made to geological science by this new doctrine. Granting, as we may, that by some of Lyell's followers it has been pushed to an excess, it nevertheless did more to set the science on a substantial footing than any other. Miracle and prodigy disappeared from the field and were succeeded by reason and logic. Baseless supposition and fine-spun theories gave place to a belief in the continuity of existing causes throughout the past and to a vast extension of that past beyond the widest limits previously assigned.

Thus geologists gradually began to see in the so-called "curiosities" of the museums of fossil-hunting "cranks" a story of the earth's life written in natural hieroglyphics. They set themselves at once to the task of reading this new language and translating its terms not, it is true, into years but into an orderly chronology. And just as the Egyptian history has gradually unfolded itself before us as the obelisks and other monuments have yielded up their secrets until now almost any tablet that is found can at once be referred to its approximate date, so the life history of the globe, imperfectly interpreted as it yet is, has become so well known that the paleontologist feels little hesitation in referring approximately to its proper horizon any specimen that comes before him. A certain facies which strikes the practiced eye at a glance and instinctively suggests their position characterizes the fossils of every era. There is no real repetition of pattern. As no sovereign has ever repeated the coin or medal of any predecessor so nature never reverts to a type that has once passed away. As Sir Lyell once observed, "she makes her casts and then she breaks the mould." Nor is there any counterfeiting. Similar conditions may occasionally recall similarity on some points, but an exact or colorable imitation of any one of these "medals of creation" is unknown.

It only followed then to associate the fossils with the rocks containing them so that when one is known the other could be inferred. This has been done and now it is easy to determine within very narrow limits the date of a stratum from an examination of the fossils which it yields. The wonderful advantage which was thus conferred upon geology needs no lengthened explanation. Instead of investigating with great labor the stratigraphic relations of the strata in any land in which he is travelling the geologist seeks to collect as many fossils as he can find, in full confidence that on his return he or some one more skilled in the science will be able to read out of them the date of the rocks that yielded them.

It will at once occur to the thoughtful reader, even if not a geologist, that it is of the very first importance that the standard of reference be absolutely correct. Hence the faunas of the different strata must be compiled from regions in which little or no disturbance has taken place. If the rocks have been displaced it may be impossible to determine correctly their original relation and naught but confusion can ensue.

This has occurred more than once in cases where the disturbance escaped notice. As instances we may quote the well known case of the Scottish highlands and that of the Taconic region in the northeastern United States. Endless discussion has followed both these errors. On the other hand the work of James Hall in the undisturbed region of western New York has resulted in establishing, on a base that can never be shaken, the whole fabric of North American Paleozoic paleontology. To this, as to an infallible standard, are referred the observations of later geologists in all parts of this continent and the agreement of the fossils is accepted without hesitation as proof of the contemporaneous or very nearly contemporaneous dates of the strata.

In a disturbed and faulted region, moreover, it would be an impossible task to decipher the history save by the aid of paleontology. The few exposures that can be obtained could seldom show the structure with sufficient detail to give any confidence and but for the evidence of the fossils this structure could in many regions never be known. For this very reason New England, although the first settled part of the country, was left blank upon the early geological maps. Only of late years, when geologists have become more numerous and investigations more minute, has the blank been partially filled up. And even now a cloud of uncertainty hangs over not a few parts of this "mother land" in consequence of the highly disturbed condition of its strata and the frequent absence of fossil remains. Yet again, so firm is our confidence in this secondary guide that in the cases, and they are not infrequent, where the fossils from a lower stratum are found on a higher level, we do not hesitate to prophesy that further research will show that the strata have been overthrown or overthrust, and such predictions have so far invariably proved correct. One slight exception may be noted, when by migration a fauna has for a time forsaken an area and a little later returned to the same. But this is a totally unimportant and local change. So sure is the paleontological record in spite of its imperfections that it will bear the stress of prophecy in cases such as the above,—the severest test that can be applied to any scientific doctrine.

Yet it should never be forgotten that in spite of its certainty the paleontologic law rests absolutely on a stratigraphic basis and if collision or apparent contradiction appears between them there is no question regarding the one that must give way. Such cases have occurred in which an excess of confidence in the secondary method has led to the misplacement of strata on paleontologic grounds. We may quote the well known instance of the *Glossopteris* flora in Australia where the occurrence of European Mesozoic plants led to the placing of the Carboniferous strata of New South Wales on too high a horizon, whereas the truth was that the late aspect of the flora was due to the earlier existence of Mesozoic species in the southern hemisphere and their subsequent migration northward. Had paleontology been born in the south the opposite mistake would have occurred. Yet more recently a similar error was made in transposing the *Olenellus* and *Paradoxides* beds of the American Cambrian in opposition to the unquestionable evidence of European stratigraphy. But an examination of the totally undisturbed strata in Newfoundland set the matter at rest and brought the two records into perfect harmony. Other similar cases might be adduced, but these will suffice to show that while the ready and comparatively easy method of paleontology is the geologist's first resort for the determination of the date of any stratum, yet the infallible standard of stratigraphy is ever kept as a reference in all cases of doubt or of serious difficulty.

If we may be allowed to use a somewhat homely and yet appropriate figure, we would say that paleontology is the timepiece of geology, serving the same purpose for that science as do our watches and clocks for the ordinary engagements of life. The time was when the only knowledge of the hour was obtained from the sun by day and the stars by night. A glance upward told, very roughly it is true, the progress of the sun across the sky, at least if the day was clear. But now very few regard the sun as a timekeeper, save rustics, hunters and woodsmen, or those living in countries to which civilization has scarcely penetrated and where the accurate division of time is unimportant and its value is small. The clock, the watch and the chronometer have superseded "Helios" in all the daily concerns of civilized life, and they perform the work much more exactly and easily than it was ever done before. A glance at the watch gives the time more readily and correctly than a look up to the sun in the sky, even when he is visible, and it is not too much to say that the multitudinous engagements of the modern world could not be carried on without our artificial timepieces. Everything would be at once slowed down to the rate that would be consonant with incessant uncertainty regarding the time of day. Yet, in spite of the manifest and manifold advantages and conveniences of clocks and watches, it is obvious that they would soon become useless were it not for constant reference to the great standard, the sun. Within their limits they are trustworthy and indispensable, but the daily check by the sun's meridian transit confers upon them all their value. Strike out this element, this standard, and in a very short time the wildest confusion would ensue. The previously faithful dial plates would indicate discrepant hours and no means, save the irregular oncoming of darkness and daylight, would remain by which to adjust them.

So it is with paleontology and stratigraphy. The former, or secondary method of determing the age of strata, is the timepiece, ever ready for instant use and giving the horizon with great accuracy and with the minimum of labor. But the latter, the absolute determinant, always stands by us as the ultimate standard of reference for testing the accuracy of the timepiece.

EDITORIAL COMMENT.

Shell-bearing Modified Drift in Great Britain.

The question of the vertical extent of Pleistocene marine submergence of the borders of Great Britain is considered by Mr. Dugald Bell in the *Geological Magazine* for last July, August, and September. He notes the abandonment by Prof. James Geikie of the former claims of the "great submergence," amounting to about 1,400 feet, which were founded on the gravel and sand beds of Moel Tryfaen, Macclesfield, and other localities, holding fragments of marine shells both of littoral and deep-water species. These beds have been shown by Belt, Goodchild, Henry Carvill Lewis, Kendall, and others, to be modified drift supplied by the melting of an ice-sheet which had transported the shells from preglacial deposits in the basin of the Irish sea.

Furthermore, Mr. Bell directs attention to Geikie's silence, in the new third edition of his "Great Ice Age," concerning the small deposit bearing marine shells found many years ago inclosed in the glacial drift at Chapelhall, near Airdrie, on which, in the second edition of that work, nineteen years ago, a depression of Scotland at least 526 feet below its present hight was confidently affirmed. It has since been ascertained, by a thorough re-examination of the Chapelhall locality, that its fossiliferous deposit was of very small extent, as if a boulderlike mass of the old sea bed had been carried there in the glacial drift.

Since this supposed evidence of a considerable submergence in Scotland during some stage of the Glacial period has failed, a new and apparently more convincing section of modified drift, holding marine fossils and underlain and overlain by till, is found at Clava, in the valley of the Nairn, a few miles eastward from Inverness. The section shows the following deposits, in descending order from the surface, which is 566 feet above the sea:

	Feet.
Light brown boulder-clay, with many striated stones.......	43
Fine yellowish brown sand, very compact, inclosing a few small stones..................	20
Dark blue or gray shelly clay, slightly bedded, with very little sand or gravel and almost free from stones, except in the lower part..................	16
Coarse gravel and sand, and brown stony clay (partially reassorted lower till)..................	36
Total..................	115

This lower till lies on the Old Red sandstone. The shell-bearing layer, 16 feet thick in this section, thins rapidly to only about two feet at a distance of 30 yards to the east, and to scarcely more than one foot at 160 yards west. From various features of these deposits, notably the rather distant derivation of the fine clayey silt inclosing the shells, though the formations of boulder-clay both below and above consist chiefly of débris of the contiguous sandstone, and on account of the absence throughout Scotland of other evidences of any submergence during Glacial times excepting about 100 feet

Mr. Bell concludes that the clay and its shells were both supplied from an ice-sheet which eroded preglacial marine beds from the basin of Loch Ness (now about 50 feet above the sea and 774 feet deep), depositing the Clava strata in a glacial lakelet held in a nook of the Nairn valley by a barrier of ice which later advanced again, forming the upper till.

Mr. Bell's view seems to be almost the same as that held by Prof. G. F. Wright and Mr. Prentiss Baldwin to account for their discovery of marine shells in the upper part of an equally thick deposit of modified drift, overlain by till, about 500 feet above the sea, at Ketley, near Wellington in Shropshire, England (*Am. Journal of Science*, III, vol. XLIII, pp. 1-8, Jan., 1892). It also well accords with the occurrence of fragments of marine shells in the modified drift forming the fore-arm of cape Cod, where a great glacial river, flowing down from the melting of our continental glacier over the present Massachusetts bay, brought these shell fragments from englacial and finally superglacial drift like that which formed the shell-bearing till of drumlins in Boston harbor and its vicinity, depositing them in the broad esker-like plateau of that part of cape Cod, when the relations of the land and the sea level there were doubtless nearly the same as now. W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Niagara Falls and their History. By G. K. GILBERT. (National Geographic Monographs, prepared under the auspices of the National Geographic Society, vol. I, no. 7, Sept., 1895, pp. 203-236, with 21 figures in the text; American Book Co.; $1.50 a year, of ten numbers; 20 cents each.) This paper is one of a series written, so far as they appear in the first volume, by Major Powell, Professors Shaler, Russell, and Davis, and Messrs. Willis, Hayes, Diller, and Gilbert, designed to supply to teachers and students of geography fresh and interesting material with which to supplement the regular text-books.

The falls, the great gorge six and a half miles long, in which the river flows between the falls and the Niagara escarpment, the upper plain bounded by the escarpment, the lower plain adjoining lake Ontario, the method of the river's work in eroding the gorge, and its relationship to the Glacial period, are very clearly and graphically described. But the question whether a large part of the drainage now passing over Niagara falls was for a considerable time diverted through outflow from lake Huron east by lake Nipissing to the Mattawa and Ottawa rivers, as

Gilbert, Wright, Spencer, and Taylor have supposed, receives only slight exposition, the opinion being reaffirmed as if under no serious doubt. To this debatable element in the history of the Laurentian lakes and Niagara river, Prof. Spencer attributes much the greater part of his estimate of 32,000 years as the duration of the Niagara river and falls.

The earliest publication on Niagara falls by Mr. Gilbert was in the Proceedings of the American Association for 1886, when, according to the recent and historical rate of recession of the falls, a conjectural duration of about 7,000 years was assigned for the time of erosion of the Niagara gorge, beginning as soon as the northward retreat of the Pleistocene ice-sheet uncovered that area, and including the whole Postglacial period. Numerous qualifying conditions in the history of the river, not susceptible of satisfactory estimate, were then noticed, some of them tending to increase and others to diminish the time thus derived from the division of the length of the gorge by the rate of its extension at the falls. On the whole, however, it seemed to be implied that 7,000 years measure the approximate duration of the river and its falls and of the whole period since the Ice age; and this was generally published as Mr. Gilbert's estimate, both in American and foreign journals, as in *Nature*, vol. XXXIV, 1886, p. 560, and vol. XXXV, 1887, p. 476.

In a more elaborate discussion of this subject, presented in the Sixth Annual Report of the Commissioners of the State Reservation at Niagara, for the year 1889 (also published in the Annual Report of the Smithsonian Institution for 1890), Mr. Gilbert refrained from stating any numerical estimate of the duration of this period, but gave much attention to the uncertainty introduced by the probable or possible outlet east of lake Nipissing. In the paper here reviewed, also, he expresses doubt that the investigations yet made can supply any reliable time estimate; though evidently the time is geologically very short, since the walls of the oldest part of the gorge are still scarcely more affected by weathering than at the distance of only one mile below the cataract.

The present reviewer, on the other hand, thinks that good reasons are found for a distrust of the withdrawal of the drainage of the upper lakes to be tributary to the Ottawa instead of the Niagara river. According to my studies, the elevated shore lines around these lakes and the directions of retreat of the ice imply that the country east and southeast from lake Nipissing to lake Ontario and the upper part of the river St. Lawrence was still enveloped by the ice-sheet as a barrier against the outflow of the Lake Huron basin, turning it into lake Erie and the Niagara river, until the Nipissing and Ottawa region was so far raised from its Champlain subsidence that the land itself, so soon as the ice blockade was removed, became a natural watershed as to-day. This view is given in the *American Journal of Science* for January, 1895, and in the Twenty-third Annual Report of the Geological Survey of Minnesota. The maps presented with these papers, and in the AMERICAN GEOLOGIST for last May and August, show how, in the reviewer's opinion, the retreating ice barrier turned all the drainage of the upper Laurentian lakes over Niagara falls from the time of their beginning until the re-elevation of the land prevented an outflow east of lake Nipissing. If this conclusion shall be sustained by future investigations, the Niagara gorge will be accepted as a geologic chronometer of Postglacial time, giving for it an approximate measure of 7,000 years, as in 1886 it was suggested to be.

It is also noteworthy that in Mr. Gilbert's paper the area of the glacial lake Warren, outflowing southwestward from lake Michigan at Chicago previous to the beginning of the Niagara river, is not regarded as including the lake Superior basin. The reviewer here again wishes to refer to his papers as just cited for support of the view, advanced most notably by Dr. A. C. Lawson, that lake Warren included the present lake Superior, reaching, indeed, during its greatest expansion, from Duluth to Buffalo and the west part of lake Ontario, thus covering the area which later has been so deeply trenched by the Niagara river. Glacial lakes, instead of marine submergence, seem to have formed all the Late Glacial or Champlain shore lines around the five great Laurentian lakes. W. U.

Undersökningar öfver Zonen med Agnostus lævigatus i Vestergotland. Af Ivar D. Wallerius. (Lund, 1895.) This memoir on the fauna of the zone at the top of the Paradoxides beds of Sweden adds very considerably to our knowledge of that narrow band of the "alum slates." G. Lindström's list of the fossil faunas of Sweden, part I. published seven years ago, gives ten species of various classes of animals as all that were known from this band at that time. The author of the present memoir has doubled the number of species, and among the genera he describes are some interesting new trilobites.

Solenopleura (?) stenometopa, whose generic name was left in doubt by Angelin, becomes the type of a new genus, *Acrocephalites*, characterized by a suture running inward to the rim of the head shield in front of the eye, a pointed front to this shield, and a small knob in front of the glabella. *Proceratopyge*, another genus, as the name indicates resembles the typical species of the Ceratopyge zone of Sweden, at the top of the Cambrian system; it differs from *Ceratopyge* in its conical glabella, its four pairs of glabellar furrows, and the triangular front fold of the rim.

A remarkable genus is the minute *Toxotis* which retains several embryonic or early larval characters, as the narrow glabella and three swellings on the front of the shield: of these the central one holds the position of the front lobe of the clavate axial ridge of the protaspis of the trilobites.* The two lateral swellings would be in the position of the eye-lobes of the protaspis as claimed by Beecher. The pygidium of this genus, by its numerous somitic lobes, shows a considerable advance beyond the embryonic or earliest larval stage of the primordeal trilobites.

*C. E. Beecher: The larval stages of trilobites. Amer. Geol., vol. XVI, pp. 165-197, Sept., 1895.

Liostracus costatus is represented with a dorsal suture quite different from that given by Angelin. Herr Wallerius takes exception to the writer's exclusion of this species from *Liostracus* and the limitation of the genus to the species with spineless cheeks, found in the basal layers of the Paradoxides beds.* But it is only in this way that the use of the generic name can be maintained and defended, as will be seen if any one will compare *L. costatus* as figured by Wallerius with *Ptychoparia striatus* Corda, the type of *Ptychoparia*. *L. costatus* is evidently a *Ptychoparia*, and this genus has precedence of *Liostracus* by eight years.

Herr Wallerius confirms the reference of the A. lævigatus zone to the Paradoxides beds by showing the presence in these slates of a form of *Paradoxides tessini* (forma "*incerta*.")

A form of *Agnostus planicauda* Ang. is described which differs from that figured by Tullberg in having the cheeks grooved in front. This would take the species out of the section *limbati*, where Tullberg placed it, and relegate it to *longifrontes*, where it would fall if one may judge by Angelin's figure. Tullberg's form would then be a variety, the type being in the *longifrontes* section.

The brachiopods figured by Herr Wallerius are allied to the ordinary forms of the Paradoxides beds. The *Obolella* (if flattened by pressure) would appear to belong to that section of the genus now set off by Walcott as *Linnarssonia*. The *Lingula*, by its outline and prominent beak, would seem to resemble the genus *Lingulella*. The three *Hyolithi* (to judge by Lindström's list, above cited) are a new feature of this zone.

The following are the species and forms which Wallerius found in the A. lævigatus zone of West Gotland :

Agnostus lævigatus Dalm.
A. lævigatus, form *armata* Linrs.
A. exsculpatus Ang., f. *sulcifera*.
A. exsculpatus, f. *integra*.
A. planicauda Ang., f. *vestigothica*.
A. pisiformi Lin.
A. fallax Linrs., f. *ferox* Tullb.
A. fallax, var. *insignis*.
Conocephalites suecicus.
Acrocephalites stenometopus (Ang. sp.)
Proceratopyge conifrons.
Toxotis pusilla.
Paradoxides tessini Ang., f. *incerta*.
"*Leperditia*" *primordialis* Linrs.
Lingula agnostorum.
Obolella parvula.
Acrotreta socialis v. Seeb.
Orthis exporrecta Linrs.
Hyolithus affinis Holm.
H. obscurus Holm ?
H. subcostatus.
Liostracus costatus Ang.

The species and forms in the above list not otherwise indicated are new ones described by Wallerius in this memoir, and its author is to be congratulated on having added so many interesting and novel types to the fauna of the A. lævigatus zone. G. F. MATTHEW.

*Cf.: Illustrations of the fauna of the St. John group, No. IV, Trans. Royal Soc. Canada, vol. 5, sec. IV, pp. 135, 136. 1888.

Iowa Geological Survey, Vol. IV, Third Annual Report, 1894, with accompanying papers. SAMUEL CALVIN, State Geologist. (467 pages, with 11 plates, 56 figures and 6 maps. Des Moines, 1895.) Aside from the administrative reports, which occupy 33 pages, the entire volume is devoted to county geology. Six counties are reported upon, and their stratigráphy, physiography and economic products are thoroughly described.

The report on the "Geology of Allamakee County" is by SAMUEL CALVIN. The area therein considered is in the northeastern corner of Iowa and is of special interest since it lies within the driftless area. Its topography is thus in sharp contrast with that of the surrounding drift-covered region, and on account of its strikingly irregular surface it has been called the "Switzerland of Iowa." The streams entering the Mississippi have cut steep sided valleys to a depth of 500 feet. The following formations occur within the county: Cambrian, represented by the St. Croix sandstone, and Ordivician, represented by the Oneota limestone, St. Peter sandstone and Trenton and Galena limestone. The only extensive lead mine ever discovered in the Oneota is located in Allamakee county, and here over 500,000 pounds of ore have been mined. The report concludes with an article on the "Forest Trees of Allamakee County" by Prof. T. H. McBride.

In the "Geology of Linn County," by W. H. NORTON, the Silurian and Devonian rocks of this district, which lies in the east central part of the state, are considered at length and the character and relationship of the different beds are fully described.

"Geology of Van Buren County," by C. H. GORDON. This county lies near the southeastern corner of the state. Its indurated rocks belong entirely to the Carboniferous, and the Lower Coal Measures (Des Moines stage) cover the larger part of its area beneath the drift. Coal is mined at several places.

"Geology of Keokuk County" and "Geology of Mahaska County," by H. FOSTER BAIN. These counties are in the southeastern portion of the state. The formations represented are the Augusta and St. Louis of the Lower Carboniferous, the Des Moines stage of the Upper Carboniferous, and the Pleistocene. The rocks underlying the greater portions of Keokuk county belong to the St. Louis stage, while those of Mahaska county were formed during the Des Moines stage. These two districts are important as coal producers. Keokuk county lies towards the eastern margin of the Iowa field and the Coal Measure strata are comparatively thin. The What Cheer district in this county is one of the more important in the state; in and about What Cheer fifty square miles are underlain by the Coal Measures. Mahaska county has long been the most productive coal district in Iowa. Thirty mines are in operation at present and about half of this number are shipping mines with an output of from 200 to 1000 tons per day, while the annual output for the county is over one million tons.

"Geology of Montgomery County," by E. H. LONSDALE. The stratified rocks of this county, which is located in the southwestern part of the state, belong to the Upper Carboniferous (Missouri stage) and Cretaceous. The beds of the latter are arenaceous in character and were named by White the Nishnabotna sandstone.

A noticeable feature of the volume is its excellent geological maps of the counties reported upon. The maps are all drawn on a scale of one half inch to the mile. The color scheme adopted by the International Congress of Geologists has been followed in general. Minor subdivisions of a formation are shown by pattern lines and where these divisions cannot be separated a solid color representing the major division is used. A. G. L.

Fossil sponges of the Flint Nodules in the Lower Cretaceous of Texas. By J. A. MERRILL. (Bulletin of the Museum of Comparative Zoology at Harvard college, vol. XXVII, [Geological series vol. III], no. 1, pp. 1-26, 1 pl., July, 1895.) This paper is the first dealing with the microscopic structure of the Cretaceous flints of America, for the investigation of flints has hitherto been chiefly confined to those of England, and has been carried on by English geologists. The specimens described by Prof. Merrill are nodules from a single locality near Austin, Texas, in the Caprina chalk of the Comanche series. The writer has regarded as proven that flint nodules have their origin in organic silica, and from this starting point directs his researches in three chief directions:

1. The identification of the fossils (chiefly sponge spicules) found in the flints.
2. The conditions of preservation of the spicules, and changes in them subsequent to deposition,—such as solution, crystallization, or replacement.
3. The method of formation of the nodules.

In the summary he draws conclusions as to the general conditions under which the flint bearing horizon of the Cretaceous was deposited.

Among the fossils, Foraminifera and sponges were found most abundantly. The Foraminifera belong chiefly to the Globigerina family, although Textularia were found in most of the sections examined. The sponge remains are mainly spicules, and it is noted as novel that the minute dermal spicules are better preserved and more numerous than the zonal varieties. Besides these easily identified fossils, fragments of what were suspected to be the shells of mollusks, and yellow plates of amorphous silica having the appearance of fish scales, were found.

In the preservation and alteration of the spicules, the writer finds a decided difference between the globo-stellate and other spicules of the dermal layer on the one hand, and the zonal spicules on the other. The latter are seldom found perfect in form or outline. In almost every case a process of crystallization has been and is still at work, changing the original organic silica to mineral silica, like that which forms the main body of the flint where no organisms can be distinguished. This crystallization takes place in two distinct zones, penetrating inward from the outer surface of the spicule, and outward from the axial canal.

The alteration from the axial canal has been quite as active as that from the outside, and in some cases is even more important. The result is that the spicules become at many points merged into the groundmass; and in places they are entirely altered, so that only their outlines can be distinguished as faint markings in the amorphous silica.

Many of the spicules of the dermal layer, however, are perfect, even to the minute barbs. The silica of these spicules is perfectly transparent, and varies in color from a light brown to a dark yellow. Only one case was found where the silica had been crystallized into the chalcedonic variety; and it is noteworthy that in this case the form was not perfectly preserved. Professor Merrill is in doubt as to whether the silica of the perfectly preserved spicules is in the original colloidal state or has been crystallized into the amorphous mineral form, but inclines to the former view.

In considering the theory advanced for the formation of these nodules it is well to remember that only three specimens, and these all from a single locality, were examined; and that, as the writer emphasizes, the conclusions are not intended as a *general* theory. In this case the theory is certainly worthy of attention. It is that "each nodule represents a separate sponge bed, in which many generations of sponges have lived and died in all stages of development." The spicules which continually fall around the base of the sponge, as the death of certain parts comes on, become consolidated in a mass which ultimately becomes a "nodule." The abundance and perfection of the fragile dermal spicules show that they have not been carried far from the original living mass: and the fact that each nodule was found to contain an abundance of "spicules peculiar to itself and rarely or not at all found in the other nodules," is very strong evidence in favor of the theory advanced. As to other circumstances which contributed to the growth of the nodules, it is noted that there were found in each specimen examined a number of spicules of varying species, which show the effects of abrasion, and which possibly were derived from some other sponge-mass; and that a considerable part of the silica was probably deposited directly from sea-water, in a gelatinous condition. This silica might come from the dissolved spicules of the parent sponge, or from silica collected at large on the sea-bottom and finally deposited around a convenient nucleus.

In regard to the conditions of deposition of the chalk, as shown by the study of the flints, the writer concludes that the flint horizons represent a definite and peculiar set of conditions; that the conditions were not those of the deepest sea, yet beyond the continental shelf.

J. F. S.

Crystallography: A Treatise on the Morphology of Crystals. By N. Story-Maskelyne. (12mo, 521 pp., Oxford, 1895.) This work treats simply of the external or morphological characters of crystals, but does not proceed to their specific applications to actual minerals, nor to a discussion of the physical properties of crystals, either mathematical or actual. Their optic properties are not presented except in a summary statement in the introduction. In the same connection brief statement is given of elasticity, hardness, cleavage and thermal and magnetic properties.

The plan of the author is very logical and progressive. While a consistency in succession of topic after topic is observable, no term is employed until it has been defined. Thus, starting from a point, which is taken as the "origin," the author builds about it in a series of growths, linked by rational and even by geometric relations, the different essentials of crystals,—axes, planes, indices, intercepts, symmetry, projection, zones, and finally all the forms of the six crystallographic systems, with their modifications by twinning, mero-symmetry, etc. A pleasant characteristic of the treatise is the paucity of mathematical reasoning. The results of mathematical processes are announced in such exact and convincing terms that, in the absence of the demonstrations, the gist and the truth of the argument are equally apprehended. Thus it is more readable than many such treatises. In this respect it is comparable to Jameson's condensed statement of Haüy's crystallography of 1801, published by Jameson in 1817. Chapter IX is devoted to the measurement and calculation of the angles of crystals and chapter X to the representation of crystals.

Altogether it is the most voluminous and comprehensive work in the English language devoted to the morphology of crystals, and perhaps marks as important a place in the progress of crystallography as that of Miller, published in 1839. N. H. W.

Einige Beiträge zur Kenntniss der böhmischen Kreideformation. By JAROSLAY J. JAHN. (Jahrbuch der k.k. geolog. Reichsanstalt [Wien], 1895, Bd. 45, Heft 1.) This memoir contains an account of the Cephalopoda of the Priesener schist (or shale) and of the horizontal distribution of this group, as well as a description of the Teplitzer and Iser schist in eastern Bohemia. The memoir is accompanied by a plate in which six varieties of the genus *Scaphites* are figured (referred to *S. geinitzi* and *S. fritschi*) and one of *Baculites* (referred to *B. faujassi*): the author also figures, but does not name or describe, a new species of this genus. The majority of the fossils of the Priesener schist are of Turonian types, though a number are Lower Senonian. On the whole it may be regarded as equivalent to the Grey Chalk of England. The Teplitzer schist is an older part of the Cretaceous. Sections of these deposits are shown by woodcuts accompanying the text, and there are lists of fossils from various localities. G. F. M.

Dictionary of Altitudes of Missouri. By C. F. MARBUT. (Missouri Geol. Survey, vol. VIII, pp. 227-316. Jefferson City, 1895.) The elevations of the various cities and towns have been determined in the main from railway levels. The altitudes as thus derived have been carefully compared and corrected to agree with various lines of precise levelling run by the Missouri and Mississippi River Commissions and the United States Coast and Geodetic Suvey. The material is arranged in dictionary form and is also given in a series of tables in which the altitudes along each railway line are given with notes showing the amount of correction applied and whence it was derived. By means of the latter tables the relative accuracy of the altitudes may be determined and new data may be easily incorporated. H. F. B.

Om Oländska Rankar. By JOHN GUNNAR ANDERSSON. (Bihang till K. Svenska Vet. Akad. Handlingar, Band 21, Afd. 2, No. 4, : Stockholm, 1895). The author, in the Journal of the Swedish Academy of Sciences, gives an account of the formation of drongs, locally called "Rankar," on the shores of the Island of Öland, in which he attributes them to marine corrasion during movements of elevation and subsidence along the Swedish coast. The formation of these isolated masses of rocks depends primarily on vertical joints in the limestone rocks of the island. Where a single joint occurs a V-shaped cut in the rock is made, but where several joints occur a channel with vertical sides is produced by the cleaving and breaking up of the layers of rock between the joints. He recognizes three stages in the production of a rank or drong such as occur on the shores of Öland : First, the weathering and splitting zone, still subject to the action of the sea (Korrasions och afspljälkning zonen): Second, the weathering zone where the action of the sea is modified or accelerated by exposure to the action of the air (Ablationszonen); Third, the finished part of the rank, which embraces the precipitous sides and flat summit of the drong more or less coated with lichens (Stilleståndzonen).

The article is illustrated with a number of wood cuts and a plate explanatory of the various processes involved in the formation of the drongs. G. F. M.

Silurisk Posidonomyaskiffer, en egendomlig utbildning af Skånes Öfversilur. By JOH. CHR. MOBERG. (Sveriges Gelogiska Undersökning. Ser. C, No. 156). Dr. Moberg in this essay describes a *Posidonomya* schist of the uppermost Silurian of Scania in Sweden which contains a limited but interesting fauna. The age is determined by three species already described which he finds in it, viz: *Posidonomya glabra* Münster, *Beyrichia steusloffi* Krause, and *Primitia mundula* Jones. He considers a new species of *Orthoceras* which the bed contains to be nearly related to *O. annulatum* Sowerby, and he doubtfully identifies *Beyrichia salteriana* Jones, and describes two new genera of ostracods, viz: *Eoconchoecia* and *Colpos.* He also finds two new species of *Cypridina*, one doubtfully referred to this genus. The author finds the young of three species of gasteropods and for this and other reasons considers the fauna to be pelagic.

The paper has a plate with excellent figures of the characteristic species, and in the earlier part of the paper the local distribution of the schist is described, as well as the nature of the deposits and the general character of the fauna. G. F. M.

New Contributions to the Knowledge of the Swedish Hälleflintas. By Otto Nordenskjöld. (Geol. Fören. i. Stockholm Förhandl., Bd. 17, No. 6, 1895.) In a previous paper (Ueber archæische Ergussgesteine aus Småland; Bull. of the Geol. Dept. of the Univ. of Upsala, vol. 1, pp. 133-255, 1894) the author has shown that a number of Swedish rocks of Archean age, hitherto denominated hälleflintas, especially from the province of Småland, are in fact volcanic, in the same manner as has been shown for some English rocks much resembling the rocks described by Prof. G. H. Williams and Miss F. Bascom from South Mountain (Pennsylvania and Maryland). At the same time it was pointed out that a great part of the Swedish hälleflintas probably are, as they have ever been considered, crystalline schists. In the hope of proving this with certainty the author has undertaken the examination of rocks from different parts of Sweden, and has succeeded in showing that the hälleflintas from Utöen are all crystalline schists, probably altered sediments, holding calcite, andalusite, wernerite, graphite, etc. The rocks from the mining district of Dannemora and from part of Hvetland (Småland) are in part schists, mostly granulitic or phorphyroidic, often mica schists, the real hälleflintas, as for instance the well known hälleflintas from Dannemora, being rather rare. In part the rocks of those districts are really volcanic and then nearly always porphyritic, the different kinds of rocks being mostly well separated, with only exceptional cases of transitions. It is very probable that they were both formed at the same time and at the earth's surface, but in a quite different manner, and that their present resemblance is due to later alteration.

The author strongly insists that the differences in these rocks make it necessary to distinguish them by different names, considering it best to keep the name hälleflinta for dense crystalline schists poor in mica, and to give, as is now ordinarily done in America and England, another name to the corresponding and often very similar igneous rocks: the difference is in fact quite as well marked as between gneiss and granite. Whether this name be the same as for the younger volcanic rocks, or a name specially applied, is of comparatively small account.

RECENT PUBLICATIONS.

I. *Government and State Reports.*

California State Mining Bureau, Bull. 7. Table showing by counties the mineral production of California for the year 1894, C. G. Yale.

II. *Proceedings of Scientific Societies.*

Proc. Boston Soc. Nat. Hist., vol. 26, pt. 4, 1895. The origin of the Arkansas novaculites, L. S. Griswold: Origin of the lower Mississippi, L. S. Griswold; The geographic development of Crowley's ridge, C. F. Marbut; Remarks on the cuspate capes of the Carolina coast, Cleveland Abbe, Jr.; Remarks on the life and work of Prof. J. D. Dana, W. H. Niles; On the southwestern part of the Boston basin, J. L. Tilton; Cerro Viejo and it volcanic cones, J. Crawford.

Jour. Cincinnati Soc. Nat. Hist., vol. 18, nos. 1, 2. Mineral synthesis, G. P. Grimsley; Manual of the paleontology of the Cincinnati group (Pt. VI), J. F. James.

Bull. Geol. Soc. Amer., vol. 7, pp. 1-16. Proceedings of the Springfield meeting, H. L. Fairchild; Champlain Glacial epoch, C. H. Hitchcock: Geology of Old Hampshire county, in Massachusetts, B. K. Emerson; Bearing of physiography on uniformitarianism, W. M. Davis: Marthas Vineyard Cretaceous plants, Arthur Hollick; Titaniferous iron ores of the Adirondacks, J. F. Kemp.

Same, pp. 17-30. Drumlins and marginal moraines of ice-sheets, Warren Upham.

Same, pp. 31-66. Glacial deposits of southwestern Alberta in the vicinity of the Rocky mountains, George M. Dawson, with the collaboration of R. G. McConnell.

III. Papers in Scientific Journals.

Ottawa Naturalist, Nov. How rocks are formed, R. W. Ells.

Ottawa Naturalist, Dec. Fossil insects from the Leda clays of Ottawa and vicinity, H. M. Ami.

Eng. and Mining Jour. Nov. 30. Granitic rocks of Missouri, C. R. Keyes.

Amer. Jour. Sci., Dec. Temperature variation of the thermal conductivities of marble and slate, B. O. Pierce and R. W. Willson: Central Michigan and the post-glacial submergence, E. H. Mudge; Devices for the separation of minerals of high specific gravity, S. L. Penfield; Stratigraphy of the Kansas Coal Measures, Erasmus Haworth; Igneous rocks of Yogo peak, Montana, W. H. Weed and L. V. Pirsson: Preliminary note on a new alkali mineral, W. M. Foote: Three-toed dinosaur tracks in the Newark group at Avondale, N. J., J. B. Woodworth: Affinities and classification of the dinosaurian reptiles, O. C. Marsh.

Science, Nov. 22. Glacial phenomena between lake Champlain, lake George and Hudson river, G. F. Wright: Dry dredging in the Mississippian sea, Charles Schuchert: Current notes on physiography (XIX), W. M. Davis.

Science, Nov. 29. Meteorology in the university, Cleveland Abbe: Geologic atlas of the United States; American fossil Brachiopoda. Charles Schuchert: Current notes on physiography (XIX), W. M. Davis.

Science, Dec. 6. Current notes on physiography (XX), W. M. Davis.

Science, Dec. 13. Geologic atlas of the United States: A glacier on the Montana Rockies, L. W. Chaney, Jr.

Amer. Naturalist, Dec. On a new species of Diplacodon. with a discussion of the relations of that genus to Telmatotherium, J. B. Hatcher; Discovery, in the Oligocene of South Dakota, of Eusmilus, a genus of sabre-toothed cats new to North America, J. B. Hatcher.

IV. Excerpts and individual Publications.

Composition of the American sulphur petroleums, C. F. Mabery. Jour. Franklin Inst., 49 pp., June-July, 1895.

Soils of Illinois, Frank Leverett. Final Rept. Ill. Board World's Fair Com., pp. 77-92, map, 1895.

The fossil Vertebrata from the fissure at Port Kennedy, Pa., E. D. Cope. Proc. Acad. Nat. Sci. Phila., 1895, pp. 447-450, Dec. 5, 1895.

V. Proceedings of Scientific Laboratories, etc.

Field Columbian Museum, Publication 5, Zool. ser., vol. 1, no. 1. On the structure and development of the vertebral column of Amia, O. P Hay. Pp. 1-54, pls. 1-3, Oct., 1895.

Same, Pub. 7, Zool. ser., vol. 1, no. 2. On certain portions of the skeleton of Protostega gigas, O. P. Hay. Pp. 55-62, pls. 4-5, Nov. 21, 1895.

CORRESPONDENCE.

A Question of Priority. My attention has lately been called to a note bearing the above title and written by Mr. W. F. Cummins, which appeared in the American Geologist for June, 1895, (pp. 395-396). As this note puts me in the entirely false position of attempting to substitute a name of my own for a formation first described and named by Mr. Cummins, it calls for a brief reply.

Some years ago I received a small collection of fossils from Phillips county, Kansas, from beds which had always been called Loup Fork. These fossils, and a list made out for me by Mr. Hatcher of those which he had collected in the same locality, proved to be very puzzling. Characteristic Loup Fork genera, like *Aphelops* and *Protohippus*, were mingled with much more modernized forms, such as *Equus*, *Hippidium* and ? *Eschatius*, while for the first time in the history of North America, South American edentates (*Caryoderma* and an unidentified genus) make their appearance. No unconformity has, so far, been reported or suspected between the strata in which this assemblage of forms is found and those of a lower level which have yielded only the ordinary Loup Fork mammals.

While hesitating whether to propose a new name for these Phillips county beds, I received Prof. Cope's report on the fossils of the Llano Estacado, which showed that nearly the same association of types occurred in Texas as in Kansas, and, as there appeared to be an unconformity implied in the introductory note, I thought a Texas name would be the more appropriate. On Prof. Cope's suggestion the name Palo Duro was selected.

Some time after the publication of the abstract of my paper read before the Geological Society of America at the Boston meeting, I first met with Mr. Cummins' paper in the Fourth Annual Report of the Texas Survey, and in writing the table of Tertiary mammals for the fourth edition of Dana's Manual of Geology I made use of the term "Goodnight beds." Prof. Dana declined to employ this name on the ground that it was a most unfortunate one. For this decision I cannot hold myself responsible.

So far as I am aware, the name "Goodnight beds" has not yet been used by others than Mr. Cummins; it is therefore quite within his power to change it for one less objectionable, and it is much to be hoped that he will do so. As the credit of the discovery is entirely his, whatever name he decides to employ will stand. I can only express regret at having unwittingly wronged him by overlooking his claims to priority. W. B. Scott.

Princeton, N. J., Dec. 2, 1895.

PERSONAL AND SCIENTIFIC NEWS.

Mr. Frank Leverett, of the U. S. Geological Survey, and residing at Denmark, Iowa, is to spend the winter in Washington, D. C.

Mr. Robert T. Hill, during December and January, is to deliver a course of seven lectures on general geology at the Catholic University in Washington, D. C.

Prof. William T. Blake, of New Haven, Conn., has accepted the professorship of geology and mining in the University of Arizona, at Tucson. He is also director of the Mining School in that University.

Mr. Charles Schuchert has recently completed his work entitled, "A Synopsis of American Fossil Brachiopoda, including Bibliography and Synonymy." It will be published as one of the Bulletins of the U. S. National Museum.

Sir J. Wm. Dawson's lecture on "The chain of life traced backward to the Cambrian age," being the opening lecture of a course on the "Beginnings of life" delivered in the Lowell Institute, Boston, is published in the December number of *Self Culture.*

The California State Mining Bureau, under the direction of J. J. Crawford, state mineralogist, has just issued, as Bulletin No. 7, a large statistical table "Showing by counties the mineral production of California for the year 1894." This table was compiled by Charles G. Yale, statistician. The total value of the mineral products was over $20,000,000, and nearly $14,000,000 of this amount is credited to gold.

The National Geographic Society has issued its program of semi-monthly Friday lectures. Many of these lectures are to be illustrated by lantern slides, and among the lecturers are some of the best known geographers of the United States. Beginning with January, 1896, the *National Geographic Magazine* will be published on the first of every month, under the editorship of Mr. John Hyde (as managing editor), Gen. A. W. Greely, Prof. W J McGee and Miss Eliza Ruhamah Scidmore. While duly recording, from time to time, all the more notable achievements in the broad field of physical and economic geography, it will be the aim of the editors to make the magazine not so much a record of the progress of geographic science throughout the entire world as an exponent of the physical, political and commercial geography of the American continent. The subscription price is $2 per year, or 25 cents per copy. Subscriptions to the Magazine and applications for membership in the Society may be sent to the secretary, Mr. Everett Hayden, 1515 H Street N. W., Washington, D. C.

Zittel's Elements of Palæontology.

It is announced that part I of the first volume of Prof. Karl von Zittel's "Elements of Palæontology" (*Protozoa* to *Mollusca*) will be published by Macmillan & Co. within a few weeks. The original edition, which appeared last May, is an admirable summary of our most recent knowledge of palæozoology. The task of bringing out a revised English edition was undertaken by Dr. C. R. Eastman, of Harvard University, in collaboration with the author and a number of the leading American and English specialists. A quantity of supplementary notes were furnished by the author and incorporated into the translation; and the various chapters have been not only thoroughly revised, but very considerably enlarged, so that the work as now planned will comprise two volumes of 600 or 700 pages.

Many original observations have been contributed by the American palæontologists who have aided in the preparation of the first volume. We note in particular the additions from the pen of Dr. Charles Wachsmuth, who has remodelled the entire crinoid and blastoid chapters conformably to the latest echinological discoveries; the able revision of the *Asterozoa Echinozoa* by W. Percy Sladen, Esq.; notes on the conodonts, by Dr. G. J. Hinde; and the highly creditable bryozoan and brachiopod chapters, which have been practically rewritten by Messrs. E. O. Ulrich and Charles Schuchert, respectively.

Part II of the first volume concludes the invertebrates, and its completion will be awaited with great interest. We understand that the following well-known investigators are engaged upon its revision: Dr. W. H. Dall, lamellibranchs and gastropods; Prof. Alpheus Hyatt, cephalopods; Prof. C. E. Beecher, trilobites; Dr. J. M. Clarke, remainder of the *Crustacea*; and Prof. S. H. Scudder, insects.

It is expected that Profs. O. C. Marsh and A. S. Woodward will coöperate with the author in revising and enlarging the second volume. The translation of the same, by Drs. Eastman and Merriam, is already far advanced. We shall endeavor to notice this work more in detail in a future number.

Underground Temperatures.

Prof. Alexander Agassiz is engaged in conducting observations on rock temperature at great depths on Keweenaw point, Mich. A recent letter of his, published in the *American Journal of Science* for December, contains much that is of interest and, as his results differ so much from the commonly accepted figures for the downward increase of temperature, we print the letter:

For several years past I have with the assistance of our engineer, Mr. Preston C. F. West, been making rock temperature observations as we increased the depth at which the mining operations of the Calumet and Hecla Mining Co. were carried on. We have now attained at our deepest point a vertical depth of 4,712 feet, and have taken temperatures of the rock at 105 feet, at the depth of the level of Lake Superior, 655 feet, at that of the level of the sea, 1,257 feet, at that of the deepest part of Lake Superior, 1,653 feet, and at four additional stations each respectively 550, 550, 561 and 1,256 feet below the preceding one, the deepest point at which temperatures have been taken being 4,580 feet. We propose, when we have reached our final depth, 4,900 feet, to take an additional rock temperature and to then publish in full the details of our observations.

In the mean time it may be interesting to give the results as they stand. The highest rock temperature obtained at the depth of 4,580 feet, was only 79° F., the rock temperature at the depth of 105 feet was 59°F. Taking that as the depth unaffected by local temperature variations, we have a column of 4,775 feet of rock with a difference of temperature of 20°F. or an average increase of 1°F. for 223.7 feet. This is very different from any recorded observations: Lord Kelvin, if I am not mistaken, giving as the increase for 1°F., fifty-one (51) feet, while the observations based on the temperature observations of the St. Gothard Tunnel gave for an increase of 1°F., sixty (60) feet. The calculations based upon the latter observations gave an approximate thickness of the crust of the earth, in one case of about 20 miles, the other of 26. Taking our observations, the crust would be over 80 miles, and the thickness of the crust at the critical temperature of water would be over 31 miles, instead of about 7 and 8.5 miles as by the other and older ratios. With the ratio observed here, the temperature at a depth of 19 miles would only be about 470°, a very different temperature from that obtained by the older ratios of over 2,000°F.

The holes in which we placed slow registering Negretti and Zambar thermometers were drilled, slightly inclined upward, to a depth of two feet from the face of the rock, and plugged with wood and clay. In these holes the thermometers were left for from one to three months. The average annual temperature of the air is 48°F., the temperature of the air at the bottom of the shaft was 72°F.

New York Academy of Sciences.

The section of geology and mineralogy of the New York Academy of Sciences held its regular monthly meeting Monday, December 16, 1895, Prof. J. J. Stevenson presiding.

The first paper was by Prof. H. P. Cushing: "Notes on the areal geology of Glacier bay, Alaska." The paper will appear in full in volume 15 of the Transactions of the Academy, but the following is an abstract:

After an introduction which outlined the previous work in the region by Dr. H. F. Reid and the writer and the petrographical determination of the rocks that had been collected by them, and that had been studied by the late Dr. George H. Williams and the writer, a description of the general geology was given, based upon a geological map.

Mr. Cushing shows that the rocks present are argillites, limestone, quartz-diorite, diorite, crystalline schists and dikes of diabase. The argillites have a wide distribution around the eastern side of the Muir Glacier basin, and also form the mountains adjacent to Muir inlet. They present three main phases: First, very hard, fine grained argillo-siliceous beds, gray to brown in color, occasionally approaching quartzite in character. Second, blue and black, somewhat slaty rocks, nearly as hard as the first, and equally fine grained, but less siliceous, although containing only a slight amount of calcareous matter. Third, thin bands of black graphitic slates, with good, slaty cleavage, and interstratified with the other two varieties. No fossils were found, although careful search was made.

The limestone is called the "Glacier Bay limestone." It is dolomitic, and for the most part extremely pure, containing only a trace of insoluble matter. Fossils were rare and so damaged by metamorphism as to be unrecognizable. But in 1893 a fossil coral was brought from the region by Prof. Stevenson, which had certainly been derived from the limestone. It was identified by Prof. H. S. Williams as a species of *Lonsdaleia*, and was regarded as demonstrative of the Carboniferous age of the beds.

The quartz-diorite is a homogeneous rock, consisting of white plagioclase, with frequent thin prisms of hornblende, and occasional biotites and some quartz. A contact was found between it and the argillites which seemed clearly an irruptive one. Other contacts oberved by Dr. Reid with the limestone indicated contact metamorphism. The diorite is a more basic rock than the quartz-diorite, and is found in the moraines. It has probably come from the mountains, which have yet proved inaccessible. The crystalline schists embrace mica schists and actinolite schists and were obtained from erratic blocks. The diabase dikes have all been intruded since the metamorphism of their wall rocks and are the latest rocks in the region. Mr. Cushing gives a detailed comparison of these rocks with other Alaskan sections, noting many parallel features and some contrasts. The paper concludes with a detailed petrographical description of the crystalline rocks.

The second paper of the evening was by HEINRICH RIES, on "The geology of Orange county, New York." Mr. Ries gave a resumé of the results obtained by him while in the field the past summer under Prof. James Hall, state geologist, to whom the report will be made. The paper was not intended for publication, but was illustrated by numerous lantern views and geological sections.

The third paper was by THEODORE G. WHITE, on "The faunas of the upper Ordovician strata at Trenton Falls, New York." This paper was illustrated by numerous lantern views from photographs.

Mr. White described the results of a visit to this, the typical locality of the Trenton formation, and of detailed study of the faunas of each stratum of the limestones at Trenton Falls and Poland, Oneida county, New York. The work was undertaken in connection with a doctorate thesis on the Trenton faunas of the Lake Champlain valley, which will be submitted in the spring to the faculty of Columbia College. The faunal lists at Trenton Falls will be published in full in the Transactions of the Academy of current date.

By making use of conspicuous and constant layers as datum planes, the thickness of the beds in the Trenton Falls gorge was found to be 331 feet. On the same creek, three miles below Poland, underlying strata were found as follows:

Black River limestone	11 feet, 9 inches.
"Dove" limestone	5 " 1 inch.
Calciferous strata	8 "

Various peculiar distortions of the beds in the Trenton Falls gorge was also shown and discussed.

The fourth paper of the evening by J. F. KEMP and T. G. WHITE, "Additional notes on the distribution and petrography of the trap dikes in the Lake Champlain region," was postponed until the next meeting, on account of the lateness of the hour.

J. F. KEMP, Secretary.

CRYSTALLINE ROCK EROSION AT THE MOUTH OF SURPRISE CANYON, PANAMINT RANGE, CALIFORNIA.

THE

AMERICAN GEOLOGIST.

VOL. XVII. FEBRUARY, 1896. No. 2.

NOTES ON THE GEOLOGY OF EASTERN CALIFORNIA.

By HAROLD W. FAIRBANKS, Berkeley, Cal.

(Plate III.)

INTRODUCTION.

The region which forms the subject of the following geological sketch lies east of the Sierra Nevadas, south of Mono lake, and north of the Mojave desert. It includes a stretch of country nearly 200 miles long and 75 miles wide. Much of it possesses a desert and forbidding character. Partly on that account and partly because of its remoteness no geological work of more than reconnaissance character has ever been undertaken. A short description of the region about Owen's and Death valleys is given by Whitney.* Parties belonging to Wheeler's survey crossed it at different times and some brief notes have been published by Gilbert.† W. A. Goodyear while connected with Whitney's survey traversed the Inyo and White Mountain ranges.‡ In the summer of 1894 C. D. Walcott made a brief examination of the White Mountain range.§ The writer spent nearly five months of the spring and summer of 1895 in the region and made the observations which form the basis of the present article.

*General Geology of Cal., vol. I.
†Geographical Surveys West of the 100th Meridian, vol. III.
‡Report of the Cal. State Mining Bureau, vol. VIII.
§Am. Jour. of Sci., Feb. and March, 1895.

TOPOGRAPHY.

The area examined forms a portion of the Great basin, offering both in climate and physical features a marked contrast to the country lying on the opposite side of the Sierra Nevadas. On the west these mountains rise with their precipitous scarp 6,000 to 10,000 feet above the valleys at their base. Eastward there occurs a series of ranges following a direction rudely parallel with the Sierra Nevadas. Thus in the northern part of the Mojave desert the low ranges run northeast and southwest. Farther north the course is north and south, finally becoming northwest and southeast through central and northern Inyo county. The valleys between these mountains form depressions successively lower towards the east until Death valley is reached. Salt Wells and Owen's valleys lie directly at the base of the Sierra Nevadas. The former has an elevation of about 2,700 feet, the latter averages over 4,000. The Panamint and Salinas valleys lie east of the Argus and Inyo ranges respectively. The former valley has an elevation in its lowest portion of 1,200 feet, while Salinas valley is probably lower. East of the Panamint valley is the Panamint range, and that is followed by Death valley which lies below the sea level. The Sierra Nevadas rise from about 8,000 feet near Walker's pass to over 14,000 in the Mount Whitney region and decrease in hight but little for more than a 100 miles northward. The Inyo range reaches an elevation of 10,000 feet, the White mountains of over 14,000, the Argus range 9,000, and the Panamint 10,000. The country is thus seen to be traversed by high ranges, which show in places very precipitous fronts and deep transverse cañons. The valleys between, often containing alkali flats, are bordered by long talus slopes extending back to the mountains. They were occupied undoubtedly by lakes at no very remote geological time.

SEDIMENTARY FORMATIONS.

These are divisible into two distinct classes. (1). Those which are comprised in the metamorphic series, including strata ranging in age from the Cambrian, according to Walcott, down through the Triassic. (2). The unaltered Tertiary and Quaternary beds.

(1). *Metamorphic Series.* This appears to constitute as far as the writer has observed the oldest rocks of the region. It has been intruded by granite, highly metamorphosed, crumpled and faulted. The rocks consist of limestone or marble, slate, mica schist and quartzite. The limestone is enormously developed wherever the metamorphic series occurs, and is probably found in all the principal horizons represented. The metamorphic series forms a part of the El Paso range, a spur of the Sierras extending eastwardly from Tehachapai. The exposures show that it has been intruded by granite, presenting as it does a high degree of metamorphism near the contact. For many miles east and northeast from this range the desert is underlaid by granite. The metamorphic rocks appear prominently in the Slate range, east of Borax lake. The ranges still farther east, extending into Nevada, and north, including the Argus, Panamint, Inyo, White Mountain and other less prominent ones, consist partly of metamorphic rocks of the type described and partly of granite.

In Modock cañon, Argus range, the contact between the granite and the limestone clearly shows the former to be intrusive, for masses of the limestone are inclosed within it. In Wild Rose district of the Panamint range as well as in Surprise cañon the granite is intrusive in the metamorphic rocks. The relation of these rocks to the granite is finely shown on the eastern slope of New York butte, one of the highest peaks of the Inyo range. Here the mountain mass rises very abruptly from Salinas valley and is cut by cañons over 2,000 feet deep. Granite forms the central portion of the range, while at varying distances down the slopes it is replaced by limestone, slate and quartzite. On the east the sedimentary rocks are thrown back in complex wavy folds, Remnants of these rocks still remain capping the transverse ridges between which the cañons, particularly in their upper reaches, have cut down to the underlying granite. The upper portions of the sedimentary series, reaching an elevation of 7,000 feet, are not folded and broken as those lower down, but rest on the granite with nearly horizontal bedding. One area of horizontal rocks in particular, between the forks of Hunter's cañon, rises in precipitous pinnacles, forming a most striking feature of the landscape. The sedimentary rocks of the Lone Pine hills are clearly shown to be older than the granite adjoining. As the contact is approached the granite becomes finer grained and is replaced by porphyritic dikes intersecting the highly metamorphosed sedimentary strata.

Walcott has described an Appalachian type of folding exhibited by the rocks of the White Mountain range.* The same structure is beautifully shown in Hunter's cañon on the eastern slope of the Inyo range and less prominently in many other places. An apparent monoclinal structure was observed in several of the desert ranges which were not visited. This is most strikingly characteristic of the Pinto range lying east of the northern end of the Panamint valley. As viewed from the Argus range at Darwin it appears to be a monocline with an enormous thickness of strata whose truncated edges face the valley.

There can be no doubt that the sedimentary strata of this whole section have been subjected to many and complex orographic movements. What is the origin of the folded structure? Did it result from the intrusion of the granite into the strata or from subsequent movements to which must be attributed the great hight and steep slope of these mountains? Judging from the manner in which the strata rest on or against the granite axes the folding in its important features dates from the earlier event, the later movements being due to faulting. The axes of the ranges in all probability date from the period of the granitic intrusion. This must have been at least as late as post-Triassic, for according to Whitney† Triassic fossils occur in the Inyo range east of Independence. Whether or not it is to be correlated with the post-Jurassic granite of the Sierra Nevadas is not certain.

Several of the ranges traversing this region are very precipitous and strongly suggest the idea of faulted blocks. The eastern slope of the Inyo range is almost as high and steep as the corresponding slope of the Sierra Nevadas. The massive granite of this range and the metamorphic strata resting against it have the appearance of having been raised bodily. Should the folded structure be due to the forcing back of the strata along the line of granitic irruption it would differ in

*Am. Jour. of Sci., March, 1895.

†General Geology of Cal., vol. 1, p. 459.

an essential aspect from that of the Appalachian mountains, for in the case of the latter the cause was no fused upwelling magma but lateral compression. Gilbert* says: "In the Appalachians corrugation has been produced generally by flexture, exceptionally by faulting; in the Basin ranges commonly by faulting, exceptionally by flexture. The regular alternation of curved synclinals and anticlinals is contrasted with rigid bodies of inclined strata, bounded by parallel faults." Many facts indicate a great elevation of the desert ranges in comparatively recent geological times, perhaps coeval with the post-Miocene elevation of the Sierra Nevadas.

In portions of the Panamint range the strata have been subjected to enormous strain, resulting in their fracture and crushing. At the mouth of Surprise cañon the rock has been so shattered that it crumbles into minute fragments on weathering. The topographic forms resulting resemble those produced in the erosion of unconsolidated deposits. The accompanying illustration (Plate III) is reproduced from a photograph of this interesting occurrence. The fine grained mica schists which are very extensively developed in the region crossed by Wild Rose cañon appear everywhere to be made up of incoherent fragments, a resulting condition of the stress to which they have been subjected. If the rainfall were greater the erosion would be very rapid.

(2). *The Tertiary and Quaternary Beds.* Little is yet known of the younger formations of the great desert stretches of southeastern California. The Cretaceous has not yet been found within the Great Basin area of the state, and if the youngest strata included in the metamorphic series are Triassic, there was a long interval during which this whole region was probably above the sea. The topography must have been vastly different from that of to-day, for there are no indications that the depressed basins were then in existence.

The Miocene occurs skirting the ranges inclosing the Mojave desert on the west, but towards the east it passes beneath the Quaternary gravels. On the northern slope of the El Paso range, between Mojave and Owen's lake, there is a series of beds of clays, sandstone, volcanic tuffs and interbedded lava

*Wheeler's Geographical Sur. West of the 100th Meridian, vol. III, p. 61.

flows. These are probably 1,000 feet or more in thickness and extend over a considerable area between the El Paso range and the Sierra Nevadas. On the north and northeast they pass beneath Salt Wells valley and the wash from the Sierra Nevadas. They are finely exposed in Red Rock cañon and about Black mountain, the highest peak of the district. The Red Rock cañon beds have been described by Gilbert,* who also gives a cross-section sketch. The beds are tilted northward at an angle of 15-20 degrees. Remnants of strata of about the same degree of consolidation appear on the south side of the El Paso range and dip in the same direction. This seems to indicate a tilting en mass of the range and adjoining country.

A seam of coal fourteen inches thick and inclosed between clay strata has been found southeast of Black mountain occupying a position apparently below the tuffs. Impressions of leaves occur in the clay immediately above the seam of coal. They were submitted to Dr. F. H. Knowlton who says: "I have looked over the three small fragments of fossil plants from the Mojave desert with the following result: Two species are represented, *Sapindus affinis* Newb., and *Anemia subcretacea* (Sap.) Ett. and Gard. The question at issue is the age of the deposits. Of course the material is hardly sufficient to warrant speaking with positiveness, but this can be said with reasonable certainty. The plants indicate a Tertiary age beyond doubt, and they seem to belong to the Eocene. Both species have quite a wide distribution geographically and are confined, with several unimportant exceptions, to the Eocene." This occurrence is very interesting because of its remoteness from any other known Eocene, and as giving a clue to the conditions existing in this section during the early Tertiary.

Although Gilbert says that the upper portion of the Red Rock cañon beds cannot be separated from the detrital slope of the Sierra Nevadas there can be no question but that they are much older, and were deposited under water. Black mountain seems to have been the pivotal point of disturbance. Finely stratified tuffs are exposed in the cañons and on its

*Geographical Sur. West of the 100th Meridian, vol. III, p. 142.

precipitous flanks. Andesite appears as flows between the beds, in dikes cutting them, and also capping Black mountain.

Three distinct movements can be traced about Black mountain. The first elevated and tilted the sedimentary strata to the north. After a period of erosion a subsidence took place with the formation of a gently sloping terrace of gravels about the mountain and extending up to within a thousand feet of the summit. Following that was another elevation which has resulted in the cutting of the present cañons in the tuffs and terrace gravel.

About Borax lake, in northern San Bernardino county, there are many distinct beach terraces rising at least 500 feet above the level of the alkali marsh. The lake which once occupied this basin was many miles in extent and left deposits of clay of considerable thickness, particularly on its western side. Its existence was probably coeval with the other Quaternary lakes of the Great basin.

The basin occupied by Owen's lake is separated from Salt Wells valley by a long narrow depression, a continuation of Owen's valley toward the southwest, which is but slightly elevated above the lake. This must have been the outlet of the lake during the high water stages of Quaternary times unless the topography has changed greatly. This depression is flanked on the east by the Coso range, the western portion of which consists of andesite, liparite, and basalt. Evenly stratified beds of volcanic ash lie along the western slope of the mountains and terminate opposite Owen's lake where they reach an elevation of at least 1,500 feet above it. If these beds were formed under water, as seems probable, there have been local changes of level of great magnitude, for no deposits were observed about other portions of the lake.

Panamint, Salinas, and Death valleys are much alike in many respects, all having been the beds of lakes during the Quaternary period. Panamint valley is narrower than the others and the alkali bottom has been obliterated through its central portion by the enormous amount of detritus from the mountains.

The Detrital Slopes of the Desert Valleys.

There is no more striking feature of all this desert region than the long gentle slopes or inclined planes which extend from the base of the mountains into the very heart of the valleys, almost covering in many cases the clayey beds of the ancient lakes. These slopes are made up of gravels and boulders spread out from the mouths of the cañons, partly perhaps at a time when the rainfall was greater but mostly by the cloudbursts of the present epoch. The climatic conditions now existing are particularly favorable for the formation of the detrital slopes, erosion being retarded but little by vegetation. The exceptionally sudden and severe precipitations of rain quickly gathering in torrential streams collect enormous amounts of material from the disintegrated surfaces and deposit it over miles of country. Thus is formed the detrital cone or fan which is sometimes 12 to 15 miles long. When the cañons are sufficiently near together the fans unite into one broad slope. In that part of the Mojave desert occupied by western San Bernardino county and eastern Kern, which seems to be underlaid chiefly by granite, erosion has reached an advanced stage with the production of excellent examples of base levelling. The rolling gravelly ridges with here and there knobs of granite, and the low granite ranges with gentle detrital slopes 6 to 8 miles long terminating in shallow alkali sinks, all point to the long continued action upon the existing topography of the agencies of decomposition and erosion. One of the best examples of base levelling is the western portion of a granite ridge lying south of the El Paso range and extending east and west for twenty miles. It is bordered by long gentle slopes of gravel and boulders, which extending upward into the shallow cañons reach almost to the summit. Viewed from a distance of ten miles but little of the mountains appears to project above the plane of deposition.

The elevated rugged mountains through central and northern Inyo county present the most striking contrast. The precipitousness of their slopes and the deep narrow cañons indicate that the forces of erosion are in their early prime. This is particularly well shown on the eastern slope of the Inyo range. The exceedingly abrupt scarp of the central portion of this range, fully comparable to that of the Sierra Nevadas, is indicative of a great elevation in recent geological times. The Salinas valley, which lies at the eastern base, has a comparatively short detrital slope on the west, while on the east and north it is eight to twelve miles long.

Excellent examples of the detrital slope are found in Coso valley which has no level bottom. Sloping planes of various degrees of inclination surround the whole valley, which is perhaps fifteen miles long and eight miles wide. All unite at its eastern side where a cañon has been cut through the Argus range, allowing the detrital laden torrents to spread out over the upper end of the Panamint valley. That portion of the valley has an elevation of about 1,500 feet, while the upper stretches of the detrital slope in Coso valley reach an elevation of nearly 6,000 feet.

The débris accumulated along the eastern slope of the Sierra Nevadas seldom exceeds five miles in width except in Salt Wells valley. Owen's valley is nearly 100 miles long and does not average more than ten miles in width, and it is probable that an enormous mass of gravel many thousand feet thick forms the bed of the valley beneath the more recent accumulations of sand.

Indications of great changes of level in recent times are not wanting in many places. Near the summit of the Argus range at an elevation of 7,500 feet there is a small patch of conglomerate with boulders, several of which are five feet in diameter, of different varieties of granite. This part of the range is formed of the rocks of the metamorphic series. Stratified gravels covering many square miles lie along the western slope of the mountains between the Panamint and Mesquite valleys. These beds have been deeply cut by the modern cañons and being unconsolidated supply a vast amount of detritus for the occasional cloudbursts. These gravels reach an elevation of 6,000 feet, extending nearly to the summit of the range.

Igneous Rocks.

The igneous rocks will be described under two heads, (1) granitic, (2) volcanic. It will be limited to the manner of occurrence and general macroscopical character.

(1). *Granitic Rocks.* The granitic rocks form the crest and eastern slope of the Sierra Nevadas as far north as Pine creek, a tributary of the upper Owen's river. From that point past Mono lake the granite is largely replaced by highly metamorphosed rocks of sedimentary origin. It is generally a biotite hornblende granite with a varying amount of glassy plagioclase. A very coarse porphyritic variety occurs about the slopes of mount Whitney. The pale flesh tinted orthoclase crystals reach a length of four inches and contain inclusions of the other constituents. Dikes of a fine grained variety intersect the coarse. Granite underlies the gravels of the Mojave desert in northwestern San Bernardino county and eastern Kern, extending north through the Argus and Coso ranges to Owen's lake. A specimen taken near the borax road between Garden station and Salt cañon shows the presence of biotite, hornblende, much quartz and orthoclase, with little plagioclase. The granite of the southern portion of the Argus range where Salt cañon crosses it is more basic. It contains an excess of dark glassy feldspar, biotite, little hornblende and quartz. It is cut by dark dikes of diorite porphyrite. The granite of the eastern portion of the Argus range contains large crystals of a flesh tinted orthoclase varying to gray, glassy plagioclase, biotite, hornblende, and little quartz. The granite of the southwestern portion of the range is a granular light colored rock with biotite, quartz, and hornblende, while plagioclase is less prominent. This rock is cut by dikes of granite porphyry. This granite extends north through the Coso mountains to Owen's lake and is probably continuous with that of the Sierra Nevadas. An axis of granite appears more or less prominent through the Panamint range. Good specimens of eye gneiss are found in the upper portion of Post Office cañon. The rock consists of lenticular eye shaped crystals of bluish feldspar with alternate bands of mica and feldspar enveloping the large crystals as in a flowage structure. A biotite hornblende granite with much quartz is very abundant in different parts of the Panamint range. A discontinuous axis of granite is characteristic of the Inyo and White Mountain ranges. Its greatest development is reached in the vicinity of New York butte and Mt. Hahn in the Inyo range. The most interesting type found here is a coarse rock with large porphyritic crystals of a brownish to grayish orthoclase, little plagioclase and quartz, and varying proportions of biotite and hornblende. A granite occurs on Blind Spring hill quite similar in character with large grayish crystals of orthoclase, biotite, hornblende, and little quartz. Titanite is quite common in the granite of the region described.

The almost entire absence of basic intrusives is a rather remarkable feature. One single occurrence was noted near the Eclipse mine, east of Independence. This is a coarse rock with a granitic structure but related to the gabbros.

(2). *Volcanic Rocks.* Tuffs of volcanic origin are very wide spread along the line extending eastward from Tehachapai to Pilot knob. Andesite seems to be the prevailing type. It occurs as flows and dikes about Black mountain.

Volcanic activity has been very pronounced in the western part of the Coso range, two or more periods of eruption being noted. To the older belong the liparites and andesites, while the younger consist of basalt. Extensive flows, so recent in origin that their surfaces have been but slightly modified, extend southward in long arms into Salt Wells valley. In the vicinity of Little lake and eastward several volcanic cones are sharply defined.

Southeast of Owen's lake there are extensive areas of lava, chiefly basalt, which are older than the similar rock in the Coso range.

Numerous flows of andesite and basalt are met with through the Argus range. Their surfaces generally form inclined plateaus on the slopes of the mountains. The superficial extent of these flows must have once been much greater, judging from the position which they now occupy with reference to the cañons. Argus gulch and its tributaries have cut through several basalt flows, one of which shows beneath an ancient river channel filled with clay and gravel.

One of the most ancient lavas observed in the region is a body of liparite forming the highest portion of the Panamint range for a number of miles.

The volcanic flows about Fish springs are perhaps of the same age as the basalts of the Coso range which they much resemble. They have been described by W. A. Goodyear.*

From Bishop creek northward toward Mono lake volcanic activity has been very intense. The most of the region for many miles south of the lake has been covered by flows of

*Report of Cal. State Mining Bureau, vol. VIII, pp. 271-272.

liparite, andesite and basalt. Andesite covers a great stretch of country about the head of Owen's river, forming the crest of the Sierra Nevadas between it and the head of the north fork of the San Joaquin river.

The writer expects to describe the microscopic characters of the rocks of this region in a subsequent paper.

THE ASSOCIATION OF THE GASTEROPOD GENUS CYCLORA WITH PHOSPHATE OF LIME DEPOSITS.

By Arthur M. Miller, Lexington, Ky.

The interest aroused by the discussions concerning the nature and origin of the phosphate deposits of Tennessee led to the carrying on of some investigations in the laboratory of the Kentucky Agricultural Experiment Station with a view towards throwing more light upon the subject. The specimens selected for examination were from three different localities, representing three different geological horizons, as follows:

Phosphate rock, bottom of Devonian black shale, Tennessee.
Limestone, lower Hudson River, Covington, Kentucky.
Phosphatic layers, top of Trenton limestone, Lexington, Kentucky.

All exhibited specimens of *Cyclora* (probably *C. minuta* Hall) in great abundance, but the Covington specimen only showed them upon the surface of the rock. The plan was to analyze the rock as a whole and then a weighed number of the fossil shells (casts) separately, and compare the percentages of phosphoric acid and lime phosphate obtained. The Devonian and Hudson River specimens of *Cyclora* could be readily picked out from the rock with the aid of a lens, but the Trenton forms would not admit of this. It was found possible, however, to apply the tests for phosphoric acid directly to the shell casts themselves as they lay embedded in this rock, and the results thus obtained were as satisfactory as in the two other cases, indicating that the phoshate of lime was confined to the casts.

The analyses were made by Dr. Alfred M. Peter, chemist of the Experiment Station, who also first directed the writer's attention to the phosphatic layers in the vicinity of Lexington.* The results were as follows:

	Cyclora casts.		Rock.	
	P_2O_5	$Ca_3(PO_4)_2$	P_2O_5	$Ca_3(PO_4)_2$
Tennessee (Devonian) specimens....	28.0	61.0	11.90	26.0
Covington (Hudson River) specimen.	22.7	49.5	.77	1.7
Lexington (Trenton) specimen.....	Very rich.		8–30	17.5–65.5

It seems evident from the foregoing that the casts of *Cyclora* are invariably rich in phosphate of lime, having indeed, in most cases, very little carbonate in them. And one can hardly resist the conclusion that in some way the phosphate owed its extraction from the sea water to these minute marine gasteropods. That the hollow shells simply offered convenient receptacles for the storing of these deposits hardly seems reasonable. It is true that phosphate of lime tends to collect in concretionary forms; the phosphatic nodules of South Carolina, those found scattered through the Black shale of Tennessee and Kentucky, and those underlying the Silurian Preston ore beds of Bath county, Kentucky, are all well known instances of this. Even where it exists in minute grains, as in the Tennessee phosphate, these appear to be concretionary in nature. But why should the molecular forces seize upon the hollows of certain species of gasteropod shells in which to display their concretionary tendencies?

Professor Safford's theory to explain the accumulation of phosphate deposits in pre-Carboniferous sediments is certainly ingenious and at the same time simple. It has much to commend it. The facts brought out by the deep sea explorations of the Challenger expedition are in accord with it. Briefly stated it is as follows:

Phosphate of lime accumulation at the bottom of the sea is in inverse ratio to the rate of sedimentation. In Tennessee and Kentucky we have Silurian and Devonian rocks which were deposited in an open sea remote from land. One foot of

*Attention was first called to the phosphatic limestone layers in the Blue Grass beds of the Trenton limestone by the late Dr. Robert Peter, chemist of the Kentucky Geological Survey and father of the Dr. Peter mentioned above. The report of the analyses published in 1877 calls especial attention to the richness of these layers and the presence in them of "many microscopic marine univalve shells." He also commented upon the presence of phosphates in these upper Trenton beds and made them the main cause of the "great and durable fertility of the Blue Grass soil."

sediment here represents in time of deposition 1,000 feet, or more, nearer shore; as for instance in New York the phosphate of lime included in 1,000 feet of sediments might well make a layer one, two, or four feet thick if accumulated over the same area devoid of other sediment. And this could be true whether the deposits are of organic or inorganic origin. If organic, however, it would seem to accord best with the theory of accumulation from the settling down to the ocean bottom of the remains of free-swimming marine animals, such as fish. The same thing would happen if free-swimming shelled animals, such as the minute Foraminifera, were phosphate of lime secreting. Perhaps the specimens of *Cyclora* found in these rocks resembled Foraminifera in this free-swimming feature. However this may be, it certainly seems a demonstrated fact that fossils of certain species of *Cyclora* are always richly phosphatic. On account of their association with phosphate of lime deposits in Tennessee and Kentucky, some of which deposits are coming into importance as sources of commercial fertilizers, these species may be considered as valuable "Leitfossilen" for the identification of such deposits.

State College of Kentucky, Dec., 1895.

THE BUCHANAN GRAVELS: AN INTERGLACIAL DEPOSIT IN BUCHANAN COUNTY, IOWA.

By Samuel Calvin, Iowa City, Iowa.

(Plates IV and V.)

About three miles east of Independence, Iowa, there are cross-bedded water-laid deposits of sand and gravel of more than usual interest. The beds in question occur near the line of the Illinois Central railway. The railway company indeed has opened up the beds and developed a great gravel pit from which many thousands of carloads have been taken and used as ballast along the line.

Overlying the gravel is a thin layer of Iowan drift, not more than two or three feet in thickness, but charged with gray granite boulders of massive size. Some of these boulders may be seen perched on the very margin of the pit, and some have been undermined in taking out the gravel and have fallen to the bottom. The surface of the whole surrounding region is thickly strewn with Iowan boulders. It is evident that the

FIGURE 1.

FIGURE 2.

THE BUCHANAN GRAVELS.

Figure 1.

Figure 2.

THE BUCHANAN GRAVELS.

Iowan drift sheet was spread over northeastern Iowa after the gravels were in place.

These sands and gravels are now so incoherent that they may be excavated easily with the shovel, and yet there is no evidence that the glaciers that transported the overlying boulders and distributed the Iowan drift cut into them, or disturbed them, to any appreciable extent. The Iowan ice sheet was probably thin, and all the loose surface materials in front of its advancing edge were frozen solid. The thickness of the gravels is somewhat variable owing to the uneven floor upon which they were deposited, but it ranges from fifteen to twenty feet. The beds have been worked out in places down to the blue clay of the Kansan drift.

Throughout the gravel bed, but more particularly in the lower portion of it, there are numerous boulders that range in diameter up to ten or twelve inches. These boulders are all of the Kansan type. Fine grained greenstones predominate. Proportionally large numbers of them are planed and scored on one or two sides. Those that are too large to be used as ballast are thrown aside on the bottom of the excavation, and in the course of a few seasons many of the granites and other species crumble into sand. The contrast between the decayed granites of the Kansan stage and the fresh, hard, undecayed Iowan boulders in the drift sheet above the gravels is very striking. Many of the boulders from the gravels are coated more or less with a secondary calcareous deposit, a feature not uncommon among boulders taken directly from the Kansan drift sheet in other parts of Iowa.

As to their origin, the Buchanan gravels are made up of materials derived from the Kansan drift. As to age, they must have been laid down in a body of water immediately behind the retreating edge of the Kansan ice. There are reasons for believing that the Kansan ice was vastly thicker than the Iowan, but the temperature was milder, and so when the period of melting came enormous volumes of water were set free. That strong currents were developed is evidenced by the coarse character of the material deposited as well as by the conspicuous cross-bedding that characterizes the whole formation. Some of the larger boulders found at various levels throughout the beds were probably not directly transported by currents, but by floating masses of ice. While, therefore, the gravels lie between two sheets of drift, and for that reason may be called interglacial, probably Aftonian, they yet belong to the time of the first ice melting, and are related to the Kansan stage of the glacial series as the loess of northeastern Iowa is related to the Iowan stage.

While the Illinois Central gravel pit is the typical exposure of the Buchanan gravels, the same beds are found widely distributed throughout Buchanan, Linn, Jones, Delaware and probably other counties. One exposure that has been utilized for the improvement of the county roads, occurs on the hilltop a mile east of Independence. Another, used for like purposes, is found a mile and a half west of Winthrop. The county line road, northeast of Troy Mills, cuts through the same deposit. Throughout the region already indicated there are many beds of similar gravels, but in general they are so situated as not to show their relations to the two beds of drift.

The Buchanan gravels, it should be remembered, represent the coarse residue from a large body of till. The fine silt was carried away by the currents, and deposits of it should be found somewhere to the southward. It may possibly be represented, in part at least, by the fine loess-like silt that forms a top dressing to the plains of Kansan drift in southern Iowa and regions farther south.

Explanation of Plates.

PLATE IV.

Fig. 1. General view of the typical exposure of the Buchanan gravels. The black loam has been stripped off and is heaped up in an irregular pile in the upper part of the view. Beneath the heap of loam is a thin band of Iowan drift, and the drift rests upon the water-laid, cross-bedded sands and gravels. The small boulders in the foreground have been thrown out of the gravel by the workmen. They are of types characteristic of the Kansan drift and they now rest on blue clay of Kansan age.

Fig. 2. Near view of the Buchanan gravels.

PLATE V.

Fig. 1. An abandoned part of the gravel pit from which the Buchanan gravels have been removed for ballast. The stratification of the gravels is obscured by rain wash. A boulder belonging to the Iowan stage is perched on the margin of the pit, and others, having been undermined, have fallen to the botton of the excavation.

Fig. 2. Field immediately north of the gravel pit, showing large numbers of Iowan boulders.

LACROIX' AXIAL GONIOMETER.

By N. H. WINCHELL, Minneapolis, Minn.

The measurement of the angle of the optic axes is one of the essential operations in the investigation of a mineral, as this property is frequently a characteristic criterion for its determination. Yet the accurate determination of this angle has alway been done by special and often large instruments, which necessarily can be found only in the best equipped mineralogical laboratories. The construction therefore of a simple device for making this measurement is an addition to the resources of the ordinary petrographer, and is welcomed by every one interested in the microscopic study of minerals.

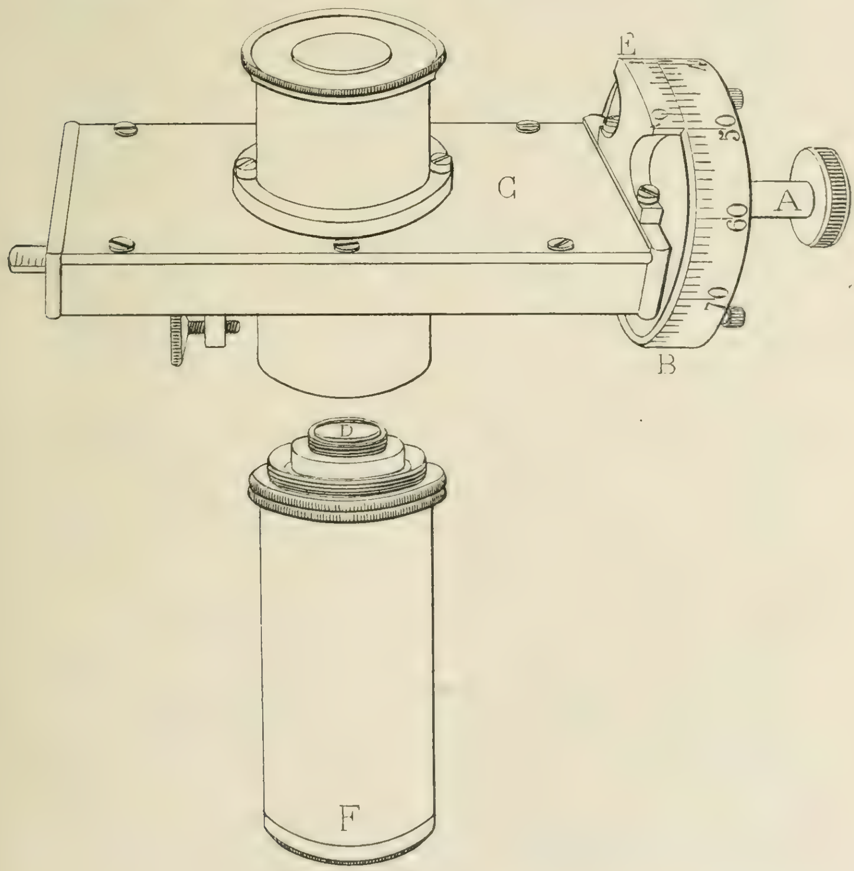


FIG. 1.

This apparatus is briefly and modestly referred to by Prof. Lacroix in the preface to his work *La Minéralogie de la France et de ses colonies*, (1893, Paris), but it has never had adequate description. It is based on the suggestion of Mallard for the construction and use of an "oculaire à fils mobile,"* and it is represented by figure 1. It can be adjusted to any microscope, since in use it is inserted in the top of the body-tube in the same manner as the common ocular. It gives the optic angle measured in air. It contains a Bertrand lens at D for magnifying the interference figure, but if the microscope have one already fitted to the lower end of the upper tube, it is often better to remove the lower part of this instrument, and with it the Bertrand lens since the lower Bertrand lens increases the interference figure, by which the delicacy of the measurement is also increased. When thus separated the lower lens T of the detached eye-piece should be screwed into the lower end of the remaining eye-piece of the goniometer. Thus adjusted it is to be used in conjunction with the Bertrand lens belonging to the microscope.†

When the interference figure is perfect, showing the loci of the optic axes, and the axial goniometer is in position, the revolution of the graduated wheel B, which is independent of that of A, will serve to bring one of the movable threads into the central point of one of the optic axes. Then by the proper rotation of A, which also carries the graduated rim B, this thread can be made to move slowly across the field and to occupy a similar position over the other optic axis. The number of revolutions and parts of revolutions can be recorded by comparison with the zero point of the vernier-scale at E.

Example for the measurement of the optic angle.

In figure 2 let O be the point of crossing of the optic axes in a thin section of a biaxial mineral AB. Let 2V represent the acute axial angle, and 2E the same angle measured in air. The angle COD is one half of 2E, or E. The distance between C and D is the sine of the angle E. It is evident that the value wanted is the distance 2sinE.

*Bul. Soc. Min. de France, V, (1882), p. 78.

†As made by Ivan Werlein, 76 rue Cardinal Lamoyne, Paris, without the Bertrand lens and the lower ocular F, fig. 1, the cost is 120 francs.

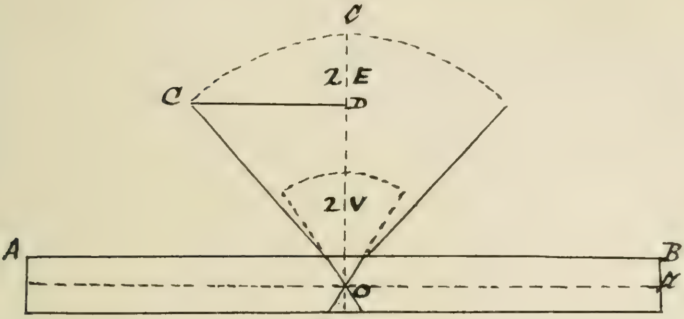


FIG. 2.

Suppose that on trial with a thin section of muscovite it is found that the distance 2sinE is divided by the revolution of the graduated rim B, fig. 1, into 1,430 parts. As these parts have no known value it is necessary to compare them with a standard. Such a standard is found in a mineral whose optic angle has been previously determined by other means. For instance, if the optic angle 2E in another specimen of muscovite is known to be 71°, then E in the same is 35° 30'.

Let the unknown distance between the loci of the optic axes in this muscovite be represented by 2d, and let the unknown ratio between its units and those of the number 1,430 be represented by M. Then

$$\sin E = \frac{d}{M}; \quad M = \frac{d}{\sin E}.$$

On measuring 2d in this muscovite it may be found to be 1,525. Hence

$$M = \frac{767}{\sin 35° 30'}; \quad \log M = \log 767 - \log 35° 30';$$

$$\log M = 3.12085.$$

Therefore, in the original specimen,

$$\log \sin E = \log 715 - 3.12085 = \bar{1}.73346.$$

$$E = 32° 46' 31''$$

$$2E = 65° 33' 2''$$

The optic angle in muscovite may vary 30°.

In making such measurements it is necessarry to use always the same objective, and to employ the same constant M ascertained for the microscope in use, which may be kept in its logarithmic form.

As the apparent size of the interference figure depends on the position of the Bertrand lens, it is necessary also to have the value of M for several positions of that lens. Hence it is convenient to make a small scale on the body of the tube by means of which it may be brought accurately into the same positions as when M was established as the standard of comparison. M thus will have a value for each position; and when these values are once determined they can be applied to other minerals at any of those positions.

When 2E is known the value of 2V can be calculated from the index of refraction by the equation

$$n \sin E = n_m \sin V,$$

n_m being the mean index of refraction of the crystal and n the index of refraction of the external medium. Hence

$$\sin V = \frac{n \sin E.}{n_m}$$

Paris, Sept. 20, 1895.

PHENOMENA OF FALLING METEORITES.

By Oliver C. Farrington, Chicago, Ill.

In the recent appreciative review made by Prof. N. H. Winchell of the Handbook and Catalogue of the Collection of Meteorites of the Field Columbian Museum, published by the writer, the reviewer propounds several queries relating to the question as to whether the so called "explosions" usually accompanying the fall of a meteorite are really due to a bursting of its mass or whether the sounds may not be referred to other causes. As the points which Prof. Winchell raises well deserve consideration in any study of meteorites, the writer desires to set forth somewhat at length his views upon the subject, though conscious of his inability to discuss it exhaustively. It should first be stated, however, that "the theory of Proctor and others, that the chondri are due to aggregations of cosmic matter," was unknown to the writer at the time of publishing the Handbook, and he has so far been unable to find an account of it in Proctor's works. The only remarks which he has found concerning the structure of meteorites are quotations of Sorby's views that the constituents of meteorites were originally in the state of vapor. A mention of these views was made in the Handbook.

1. "Is not the idea that meteorites explode," asks the reviewer, "producing the detonations which accompany their fall, traditional and imaginary rather than actual?"

It is doubtless possible that sounds like those of an explosion may be generated during the fall of a meteorite without any exploding of the meteorite itself. In this case it is important, of course, to guard against mistaking a similarity of sound as evidence of the fact of explosion. But I believe it may also be asserted, from evidence so reliable that the nature of the occurrence cannot be doubted, that the actual "explosion" or breaking up of meteorites in the air has been seen to take place.

Prof. H. A. Newton, in a lecture on the Relation of Meteorites to Comets, published in *Nature* (vol. 19, p. 315), mentions a number of instances of this kind. The meteorite which passed over Illinois, Dec. 21, 1876, was seen by hundreds of persons to fly into fragments, lighting up the sky with a burst of celestial fireworks. Its passage was accompanied by the sound of fearful explosions. The meteor which passed over Georgia and Tennessee in 1860 behaved in a similar way. Prof. Newton states that the Iowa County meteorite, of Feb. 12, 1875, was seen to break up in the air and later by one and a half to two minutes five quickly recurring reports were heard from it. Dr. J. Lawrence Smith states,* from evidence gained from eye witnesses of the fall of the Emmet County meteorite, May 10, 1879, that "there were distinctly two explosions. The first took place at a considerable height in the atmosphere and several large fragments were projected to different points over an area of four square miles, the largest mass going farthest to the east. Another explosion occurred just before reaching the ground and this accounts for the small fragments found near the largest mass." At the fall of the Fomatlan meteorite Sept. 17, 1879,† "many saw and heard the explosion. Two or three fragments fell eight miles N. W. of Fomatlan between the houses of the Gargantillo farm. The main body of the meteorite, which must have been very large, continued on its path to the N. W. and fell into a large lagoon four or five miles distant from the farm."

Two scientific persons commissioned by the Government at Pesth to inquire into the circumstances of the meteoric fall at Knyahinya, June 9, 1866, reported‡ that "at Eperies, fifty-five

*Am. Jour. Sci., III, vol. xix, p. 460.
†Am. Jour. Sci., III, vol. xxx, p. 108.
‡Abstract in Proc. Brit. A. A. S., 1866, p. 133.

miles west of Knyahinya, the meteor presented the appearance of a burning birch rod. The handle, which was directed foremost, was deep red; and the meteor shot over Saros and Zemplin to a point due east, where it burst, scattering its fragments in all directions and houses shook with the explosion."

The bursting of the Quenggouk meteorite, Dec. 27, 1857, was observed by Lieut. Aylesbury and others, and the former has left a sketch showing its appearance at the moment of explosion. Haidinger,* after careful study of all the observations, states that "there can remain no doubt that the meteorite, entering our atmosphere as a complete stone, was broken into a number of pieces at a great height."

Other instances of this kind might be cited, but those which have been given ought to be sufficient to prove that meteorites have been seen to "explode" during their passage to the earth. I can find, moreover, no other adequate explanation for the differences in crust observable on different parts of single meteoric stones than to suppose that, by the breaking up of the mass during its passage through the atmosphere, some surfaces were exposed for a much shorter time than others to the fusing forces. As stated in the Handbook, the stones of the Butsura fall furnish the most remarkable instance of this, for their surfaces show three different degrees of fusion, apparently corresponding to three different disruptions indicated by the three reports heard at the time of the fall. But the stones of almost every meteoric shower show, in connection with thoroughly fused surfaces, others which are barely smoked and indicate very brief exposure. Haidinger, I am aware, sought to explain these surfaces by supposing them to be the result of mutual collision of fragments during a fall; but the extent of the surfaces and the absence of any evidences of abrasion upon them seem to me to contradict such a theory.

It may of course be incorrect to assert that the sounds like an explosion, which are heard, are concomitant with, or are the result of the bursting of the meteorite, yet the inference is a natural and usual one.

*Sitz. Akad. Wien., Bd. 44, S. 637.

2. "Is not the noise due to the atmospheric agitation produced by the impact?" This point will be discussed later.

3. "Is there anything naturally or possibly explosive in the interior of the meteorite?" Yes. (a) The heterogeneous minerals making up the mass of a meteorite possess different degrees of conductivity and vary as to their coefficients of expansion. Some of them contain gas and perhaps liquid inclusions. The effect of heating the surface of such a mass to incandescence, while its interior remains cold, will be to generate internal strains quite similar to those produced in a glass rod when its exterior is suddenly heated. The same result, therefore, may be expected,—the mass will fly to pieces. The bursting, often with considerable violence, of stones when heated is a phenomenon familiar to any farmer's boy who has built a fire near a rock, or dropped a stone into a fire; and, except that the heat is much less intense and therefore a less violent action can be expected, it is quite the analogue of the explosion of a meteorite. (b) The gases occluded in meteorites, often under considerable pressure (Handbook, p. 18), would, when suddenly expanded by heat, tend to rend the mass in which they were enclosed.

4. "Is not the fact that the interior of the mass is usually cold, sufficient demonstration that the exterior only has been heated and hence, also, that it has suffered the greater amount of expansion?"

It is probably true, except in the metallic meteorites, that the exterior only is heated, but this very contrast of temperature is just what is required to bring about the conditions of strain and forces producing rupture referred to above.

5. "In the firing of a cannon is it the 'explosion' proper that is heard, or is it the atmospheric undulation which is produced by the rush of the column of liberated gas into the still air?"

For the production of sound three elements are necessary, a vibrating body, a conducting medium and a receiver. When gunpowder is fired the sudden expansion and immediate contraction of the gases generated set the air in vibration and produce upon the ear the sensation of sound. "The 'explosion' proper" that is heard, therefore, *is* the atmospheric undulation produced by the sudden expansion and contraction of the air. If not, what is it?

6. "Would it be possible for a loosely cemented stone, like most meteorites, to fall upon the atmosphere, with the speed with which meteorites travel, without disintegration? Would it not necessarily crumble into many pieces, in the same manner and for the same reason that a pailful of water, suddenly liberated at a hight, is divided into many parts and perhaps into spray before it reaches the earth?"

It is hardly correct to consider most meteorites as "loosely cemented;" for many, even of the stones, have an almost dioritic toughness and break with difficulty. But even if their texture be regarded as comparatively fragile, the fact that single masses of meteoric stones weighing from 400 to 600 and perhaps 1,200 pounds have come to the earth, shows that the "spray" to which they have been reduced has been comparatively coarse, and that the violence of their impact has not been such as to entirely disintegrate them.

7. "Cannot the different explosions of meteorites be all attributed to the passage of so many large masses through the air, or to the atmospheric agitation of their impact on the lower air?"

The fact that so many different theories have already been proposed by eminent authorities to explain the sounds like an explosion heard at the fall of meteorites indicates that the cause of those sounds is likely to be for some time a matter of individual opinion. Haidinger* regarded the detonation as due to "the sudden irruption of the surrounding atmosphere into the vacuum of the igneous globe when the action of the vis viva of the movement had reached its term." J. Lawrence Smith† believed the noise to be produced by "concussion of the atmosphere arising from the rapid motion of the body through it, or in part due to electric discharge." Prof. H. A. Newton‡ has explained it by saying that "the pressure of the air cracks the stone,—perhaps scaling off small fragments, perhaps breaking it into pieces of more uniform size. In the latter case the condensed air in front of the meteor being suddenly relieved will expand, giving the terrific explosion which accompanies such breaking up." Dr. Flight§ says that "the

*Philosophical Magazine, April, 1869.
†Am. Jour. Sci., III, vol. xxxi, p. 98.
‡Article on Meteorites, Encycl. Brit.
§Introduction to the Study of Meteorites, 1890, p. 21.

sudden generation of heat and the consequent expansion of the outer shell account not only for the breaking up of the meteorite into fragments, but partly also for the crash like that of thunder, which is a usual accompaniment of the fall." Profs. Maskelyne and Dewar have expressed similar views.

In the view of the writer, the sound ordinarily to be expected from the passage of a meteorite will be like that of thunder, such as follows a stroke of lightning. The phenomena are similar, as pointed out by Mr. Hirn,* in that a sudden heating and expansion of the air takes place, followed by a violent contraction; and thus are caused vibrations which are transmitted to the ear. Inasmuch, however, as this column of heated air is many miles in length, the sound will not all reach the observer at once but will be prolonged into a long roll as the vibrations from more distant parts of the column come to him.

But this view does not preclude the possibility that additional sharp, explosive sounds should arise from a bursting of the mass when fragments of a great size are hurled outward suddenly and with great force. These should produce still more distinct vibrations whose character would be recognized as differing from that of the general sound.

Since most meteorites are marked upon their surface by pittings which have been shown by Daubrée to be similar to those found on masses of steel upon which dynamite has been exploded, it is reasonable to suppose that the masses have been acted upon by similar forces, and that if a detonation accompanied the action of the one it did that of the other. While such reasoning from analogy can rarely be accepted as conclusive, the writer is inclined to believe that detonations may accompany the fall of a meteorite without any bursting of its mass. It is also his belief, however, that when such bursting does occur it will produce a sound like that of an explosion.

8. "Would it be possible to produce the detonations heard at the time of fall, by the separation of the meteoric mass into parts and at the same time not reduce it to powder?" There seems to be irrefutable evidence that meteoric masses have separated into parts at the time of fall without being reduced to powder, and that such falls have been accompanied by detonations.

*Nature, vol. xxxv, p. 303.

9. "Would not the sudden arrest of a mass of matter like a meteorite produce a noise similar to that heard by the sudden action of the force which starts a cannon ball? Would not the resistance of the air be such as to cause a comparatively sudden arrest of the motion of a meteorite?"

The arrest of the motion of a meteorite by the atmosphere may be regarded as comparatively sudden, yet there is a slowing down of its velocity as the meteorite passes continually into a more dense atmosphere, so that it falls to the earth with a speed comparable to that of an ordinary falling body. In several ways, however, the agencies producing sound differ in this case from that of the force which starts a cannon ball. The latter is local in its effect and of but momentary duration. The passage of a meteorite, on the contrary, as previously noted, leaves behind it a long narrow column of expanded air whose subsequent contraction will bring to the ear a long continued sound. The character of the sound will depend upon the hight of the meteor, its size, velocity and the configuration of the country over which it passes.

Could a cannon ball, which, moving at the velocity ordinarily given to it, whistles, have imparted to it a velocity of 100,000 meters per second, it would no longer whistle, it would thunder. Conversely, meteorite fragments which ordinarily fall at a velocity so great as to thunder, will, if their velocity is decreased, produce only whizzing, whistling sounds. The fact, therefore, that sounds like the "whistle of a rifle bullet," "the hum of a locomotive," "the tearing of linen" and the "flapping of wings" frequently accompany the fall of meteorites, proves the arrest of motion of some of the fragments at least to have been simply such as to slow down their velocity.

Some meteorites, moreover, have fallen without any explosive sounds. That of Mazapil, for instance, gave only a loud hissing noise, "exactly as if something red-hot had been suddenly plunged into cold water." At the falls of Segowlee, St. Denis-Westrem, Shalka, Gross Diwina, and others, only low rumblings were heard.

If the arrest of the meteorite by the atmosphere were the only cause of explosive sounds, it would seem that these should be as constant an accompaniment of a fall as the report of a gun or cannon is of its discharge.

The sounds attending the discharge of some forms of ascending fireworks, such as rockets and star showers, though they occur in reverse order, seem to the writer to have an origin similar to those accompanying the fall of meteorites. There is first a whizzing noise from the motion of a projectile through the air at a velocity of about 250 feet per second. Then the projectile is seen to burst, and the report of the explosion follows sometime after the discharge itself. In this case there can be no doubt that the report comes from the explosion "proper." Whatever be the limitations of this analogy, it may at least be well to point out that observation of the flight of sky rockets and other fireworks may afford excellent practice in determining the position, angular altitude, velocity and distance of luminous bodies in motion, so that one who has gained skill in noticing these points may be able to record with accuracy the phenomena which attend the fall of a meteorite, whenever it becomes his good fortune to witness such an event.

Field Columbian Museum, Jan. 7, 1896.

PHILADELPHIA MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

By WARREN UPHAM, St. Paul, Minn.

The eighth winter meeting of the Geological Society of America was held in the Art Department rooms of the main building of the University of Pennsylvania on Thursday to Saturday, December 26th to the 28th, 1895. Sixty fellows were in attendance. At the same time six other societies held meetings in other rooms of the University, namely, the American Society of Naturalists, the American Morphological Society, the Association of American Anatomists, the American Physiological Society, the American Psychological Association, and the American Folklore Society. In all two hundred scientists or more participated, coming together for comparison of ideas and renewal of old acquaintance from widely distant parts of the United States and Canada.

Prof. N. S. Shaler, president of the Society, presided at its meetings, and delivered his retiring address (the seventh in the ensuing list of papers) on Friday afternoon. The officers elected for 1896 are Joseph LeConte, of Berkeley, Cal., president; C. H. Hitchcock, of Hanover, N. H., and Edward Orton, of Columbus, Ohio, vice-presidents; H. L. Fairchild, of Rochester, N. Y., secretary; I. C. White, of Morgantown, W. Va., treasurer; Joseph Stanley-Brown, of Washington, D. C., editor; and B. K. Emerson, of Amherst, Mass., and J. M. Safford, of Nashville, Tenn., new members of the council.

Seven new fellows were announced as elected, namely, H. Foster Bain, of Des Moines, Iowa, assistant on the Iowa geological survey; William K. Brooks, of Baltimore, Md., professor of zoölogy in Johns Hopkins University; Charles R. Eastman, of Cambridge, Mass., assistant in paleontology in Harvard University; Henry B. Kümmel, of Trenton, N. J., assistant on the New Jersey geological survey; William H. Norton, of Mt. Vernon, Iowa, professor of geology in Cornell College; Frank B. Taylor, of Fort Wayne, Ind., engaged in Pleistocene geology: and Jay B. Woodworth, of Cambridge, Mass., instructor in Harvard University.

The Society now numbers about 230 fellows, and it has lost seventeen by death, four of these during the year 1895. Memorials of these recently deceased members were presented as follows: of James D. Dana, by Joseph LeConte (read by H. S. Williams); of Henry B. Nason, by T. C. Chamberlin (read by Bailey Willis); of Albert E. Foote, by George F. Kunz (read by J. F. Kemp); and of Antonio del Castillo, by Ezequiel Ordonez (read by secretary Fairchild.)

The committee on photographs reported 203 additions during the year. The total collection owned by the Society and exhibited at this meeting numbers 1283. This committee solicits donations, which may be sent to the chairman, Dr. George P. Merrill, of the U. S. National Museum, Washington, D. C. They will be duly acknowledged in the publications of the Society.

It was voted that, in the summer meetings with the American Association for the Advancement of Science, this Society shall hold only business sessions, and that the papers then presented shall be read only by title. These papers, it is urged, should be read and discussed in Section E (Geology and Geography) of the Association, but they may be accepted for printing in the Bulletin of the Society. Much attention will be directed in these summer meetings to field studies of important localities and especially remarkable features of the geology of the surrounding country, by joint excursions of the Society and the Association.

Twenty-seven papers were presented at this meeting, of which we are enabled to give the following abstracts, with notes of ensuing discussions, through the kindness of the authors, and with much aid from the preliminary announcements distributed to the fellows of the Society, and especially from the report by Prof. J. F. Kemp in *Science* (new series, vol. III, pp. 46-57, Jan. 10, 1896). The order is that of the program.

Disintegration and Decomposition of Diabase at Medford, Mass. GEORGE P. MERRILL, Washington, D. C. (Read by title.) The paper deals with the chemical and physical changes which have taken place in the process of breaking down of the diabase as displayed at Medford. It gives analyses of fresh and decomposed materials and calculations showing the percentage amounts of the entire rock and of each constituent removed through solution. The decomposition is regarded as wholly postglacial. In closing some exceptions are taken to the commonly accepted view that decomposition is more rapid in warm than in cold climates.

The Geographic Relations of the Granites and Porphyries in the eastern part of the Ozarks. CHARLES R. KEYES, Jefferson City, Mo. (Read by title.) As introductory, a brief statement of the general geologic features of the region is presented. A summary of opinion is given regarding the origin of the massive crystallines and their present configuration: the results of recent investigations are also mentioned. The physiography of the district is outlined: there are recognized the Tertiary peneplain forming the general surface of the Ozark dome, and a lowland plain of denudation at a level 800 feet below the great one. The relations of the principal types of acid rocks to the lowland plain are pointed out. Incidentally, attention is called to the fact that the geological age of the granite rocks is probably not Archæan, as it has been heretofore generally considered. The absence of gneissic and schistose rocks in the massive crystalline area is a noteworthy fact. It is particularly suggestive in the light of the recent discovery in a deep well boring near Kansas City of real evidences of squeezed rocks. The hole, which was made by a diamond drill, reaches a depth of nearly 2,500 feet. The core at the bottom is one and seven-eighths inches in diameter. The last thirty feet are reported to be in the rock which examination shows to be a black mica schist, the cleavage planes of which have a dip of 35 degrees. If the natural inferences are correct, the entire Paleozoic sequence from the base of the Upper Coal Measures has been passed through in a vertical distance of less than half a mile: the schistose floor upon which rest the unaltered sedimentaries has been reached in Missouri; and Archæan rocks are present which are not unlike those of the more typical areas in other parts of the American continent. This being the case, the normal and unchanged granitic rocks of the St. Francois region probably do not belong to the Archæan at all, but to that recently established system which represents the enormous interval of time between the formation of the truly azoic rocks and the deposition of the lowest Cambrian.

Recapitulating briefly, it may be stated that:

1. The granites and porphyries are very closely related genetically, and are to be regarded as facies of the same magma.

2. Whatever may have been their origin, whether from a few or many points of extravasation, the present relations of the two are that the porphyry is an upper and surface facies of the granite, the thickness of the former being variable, having been originally unequally developed in different places and subsequently modified by both ancient and recent erosion.

3. The present geographic distribution of the granites and porphyries is the outcome of very recent changes in the topographic configuration and is not of very ancient origin, as it appears to have been usually regarded.

4. The existing areal relations of the principal masses of the acid rocks may be traced directly to the systematic and widespread physiographic effects of recent orogenic action.

5. An element of uncertainty regarding the geological age of the massive crystalline rocks now prevails, and an exact determination may always remain a problem.

6. The basal complex of Archæan schists exists in the region within a very moderate distance beneath the highest Paleozoics. It differs widely in lithological characters from the crystallines usually referred to that age in the State, but closely approaches the more typical Archæan rocks of other districts.

Illustrations of the Dynamic Metamorphism of Anorthosites and related rocks in the Adirondacks. J. F. KEMP, Columbia College, New York City. The high central peaks of the Adirondacks and the larger outlying ridges consist of anorthosite, a coarsely crystalline rock that is nearly pure labradorite. Though described as norite in earlier reports, it is noticeably poor or entirely lacking in ferro-magnesian silicates. In the course of a fairly extensive reconnoissance of the principal portion of the mountains, the writer has met but a limited exposure of the anorthosites in an uncrushed condition. Specimens of such were shown, and beginning with these as a starting point the gradual development of crushed rims was shown, which, at first barely discernible, increase until the original crystals of labradorite are but small nuclei. The extreme is a "pulp-anorthosite," with no nuclei. The passage into gneissoid forms, through augen-gneisses, and with a rich development of garnets, was also illustrated. The final result is a thinly laminated gneiss. Comments on the areal distribution of these types were added. From a series of basic gabbros a gradual passage was shown, by specimens, into gneissoid types in the same exposure.

Profs. A. C. Lane and C. H. Hitchcock, in discussion, brought out the facts that in the gabbros the change to gneiss is generally marked by a passage of pyroxene to hornblende, and that the igneous series, though called Upper Laurentian by Prof. Kemp in following the Canadian usage, is doubtless of later age than the crystalline limestones of the region, which would be called Algonkian by many geologists of the United States.

The Importance of Volcanic Dust and Pumice in Marine Deposits. N. S. Shaler, Cambridge Mass., Considerations based on the volcanic action in the Java district make it probable that the extrusions of rock matter in the form of dust and pumice may exceed that which is carried to the sea by the rivers and possibly equals that which is conveyed to the ocean by all other actions. Observations on the shore of the United States afford evidence that there is a noticeable contribution of pumice to the deposits forming along that coast line. The facts warrant the supposition that the value of these volcanic contributions to sedimentation has not been properly appreciated.

In the ensuing discussion, Prof. Hitchcock, referring to the discoveries of pumice along the southern coast line of the United States, remarked that in his observations in the West Indies he had found no pumiceous rocks among the volcanics, and suggested the possibility of remoter sources.

Dr. C. W. Hayes spoke of the vast formation of volcanic tuffs seen by him in eastern Alaska, extending over many hundred square miles and up to 75 feet thick. Its bulk he estimated as more than a hundred cubic miles. He also referred to the top layer of the Devonian rocks in the southern Appalachians, regarded as a volcanic tuff, which varies from 8 to 18 inches in thickness and reaches from eastern Tennessee and Georgia to Arkansas and Missouri.

Dr. L. V. Pirsson mentioned the wide area over which the fine dust ejected from Krakatoa was spread, and also noted Bäckstrom's detection of volcanic dust in the sea beaches of Norway. Much of the latter is demonstrably from Iceland. Caution is needed against being misled by artificial slags and cinders.

Dr. M. E. Wadsworth cited the tuffs collected by Garman, Merrill, and Diller in Nebraska; and Dr. Persifor Frazer recalled the collection of dust by Wharton in Philadelphia from the first snowfall of December, 1883, agreeing entirely in its microscopic characters with samples from Krakatoa, where the most remarkable volcanic eruption of this century had occurred in August of the same year.

Commenting on the length of time during which volcanic dust may remain suspended in the atmosphere, Prof. W. M. Davis stated that the peculiarly colored sunsets following the Krakatoa outbreak lasted through 1884 and that the so-called Bishop's ring was visible around the sun for fully two years.

Prof. Shaler mentioned the observations in Germany, after the Krakatoa eruption, of shining clouds at first having an elevation of 80 miles in the air and later rising to 140 miles before they disappeared.

He also reminded the Society that similar brilliantly red sunsets followed the great eruption of Skapter Jokul in 1783.

Prof. HITCHCOCK suggested that red glows due to aqueous vapor should not be confused with colors from volcanic dust, as the latter are prevailingly greenish; but in reply it was brought out that the colors are due to diffraction, and that the reds may also be caused by fine particles of mineral matter.

A needed term in Petrography. L. V. PIRSSON, New Haven, Conn. Since the term *crystal*, when strictly used, means a body possessing not only a certain internal molecular structure, with definite physical properties, but more especially an outward symmetrical form with plane faces, it is evident that there is no good term for the rounded or formless masses in which minerals occur in rocks. Therefore, after consultation with Prof. E. S. Dana, the term *anhedron* (meaning without planes) is proposed for these formless masses which possess the internal structure of crystals; and such minerals may also be spoken of as having an anhedral development.

In a brief discussion that followed, the term was on the whole well received, although the general feeling was strong against the introduction of further new terms into the over-burdened nomenclature of petrography.

The Cerillos coal field of New Mexico. JOHN J. STEVENSON, New York City. (Read by title.) This paper describes a small portion of the area formerly known as the Placer coal field, south from the Rio Galisteo and about 25 or 30 miles south from Santa Fe, New Mexico. The only rocks within this area are Laramie and eruptive. The latter proceed from the laccolite known as the Placer or Ortiz mountains and occur in two sheets separated by about 400 feet of Laramie beds. These sheets, each about 200 feet thick, are intruded between the stratified rocks and follow their dip closely. The rock has been identified by Prof. Kemp as trachyte, but closely allied to andesite. The Ortiz or Placer mountains are about two miles from the most southerly locality visited.

The column of Laramie exposed is not far from 1,000 feet thick and contains several coal beds of economic importance, only three of which are discussed in this paper. The highest bed, about 900 feet from the base of the column and known as the *White Ash*, has been opened at many places along the principal gorge, Coal cañon. At the most northerly mine, the White Ash, its coal is bituminous, containing 39 per cent. of volatile combustible, but at the Lucas mine, not more than 3,000 feet farther up the cañon, it is anthracite with only 1 per cent. of volatile. The interval between these mines contains for the most part coal so crushed as to be practically unmarketable; but, as shown in one level of the White Ash mine, the transition from soft to anthracite coal is gradual. Farther up the cañon, toward the Ortiz mountains, the coal becomes harder and at one opening resembles the Rhode Island anthracite.

The lower important bed on Coal cañon is the *Cook-White*, which is not mined at present. It shows the same changes, being distinctly anthracite at the old openings up the cañon, but becoming bituminous lower down, where it contains 30 per cent. of volatile.

A small bed, midway between the *White Ash* and the *Cook-White*, shows no variation, being bituminous at the most southerly point visited, although the *White Ash* is anthracite in the same locality. But this bed is much cut by clay seams and is not continuous.

The cause of the metamorphosis of the coal is contact with eruptive rocks. The clay seams of the smaller bed prevented transmission of the heat and changes in the coal. Actual contact with the molten rock appears necessary to produce change, for the upper sheet of trachyte comes down to within a few feet of the *White Ash* and evidently has no affect upon its composition ; the transition from bituminous to anthracite in that coal bed is regular from the north southward under the sheet and apparently in no greater ratio than in the *Cook-White*, 150 feet lower, which in turn is fully 200 feet above the lower sheet.

The Relations of Geologic Science to Education. N. S. Shaler. (Presidential address.) In teaching geology it is necessary that a large part of the instruction shall be given in the class room: but a real, living interest in the science can only be gained by actual work in the field. The true way to learn geology is by reading the book of nature in the open air, with supplementary museum study and practice in the laboratory. [This address will be published in an early number of *Science.*]

Note on the outline of Cape Cod. W. M. Davis, Cambridge, Mass. Observations made during an excursion with the Harvard summer class in physical geography last July, supplemented by a study of the Coast Survey charts, lead to an interpretation of the changes suffered by Cape Cod which differs in certain respects from that offered by Whiting (Coast Survey Report, 1867) and by Weule (Zeitschrift für wiss. Geographie, 1891). Provincetown, the sandy northern part of the cape, long recognized as an addition by current, wave, and wind, to the high "mainland" of the cape in Truro and farther south, is regarded as growing by additions on the northeastern or outer side: the accretion here being correlated with the rapid retreat of the cliff along the eastern side of the "mainland," and a fulcrum of no or small motion being located near Highland Light. Race point, the extremity of the Provincetown area, manifests its external addition to the rest of the sandy area by enclosing a lagoon that narrows eastward.

At present, still another bar is growing along the outer side of the Race point bar. As a consequence of this, the sand is not now washed southward around Race point so plentifully as before this unfinished external bar was begun: and the southward reaching bar or hook that curves around to Long point and encloses Provincetown harbor is not so well supplied with sand as formerly. The present washing of the latter bar, north of Wood End, is ascribed to this lack of supply, rather than to any increased activity of attack by the waves. The west side of the "mainland" is cut into by a flat concave curve: this being a slight change from a former straighter shore line, on which the waves and currents were working before the building of Provincetown.

Mr. G. K. GILBERT, in discussion, asked whether there is any evidence of general elevation or depression of the cape area; to which the speaker replied that there is none.

Prof. HITCHCOCK recalled the idea of Louis Agassiz that there was once a continuous line of drift from Cape Ann to the forearm of Cape Cod; but Prof. DAVIS said it has been long disproved, and referred also to historic records of low sand islands off to the southeast of the Highland Lighthouse.

Prof. SHALER stated that the "mainland" of the cape was formed by a deposit of drift on a preglacial ridge of Tertiary and Cretaceous strata, and that the former river systems can be traced southward through Vineyard sound. The Provincetown people fear lest the cape to the east of them will be breached and their harbor be filled with sand; and the value of jetties north of the point of attachment between the Provincetown sand area and the high land of modified drift was emphasized.

Plains of Marine and Subaërial Denudation. W. M. DAVIS. In regard to the origin of plains of denudation, there prevail in Europe and this country two schools of belief: the European school, attributing denuded plains to marine action, follows Ramsay and Richthofen; the American school, looking to subaërial denudation for the same result, follows Powell, Dutton, and others. Plains of marine denudation are thought to attain their greatest extent in regions of slow depression, where the activity of the waves on the coast is continually maintained by the deepening of offshore water that would otherwise become very shallow. When elevated, perhaps to the attitude of plateaus, the plains retain for a time an unconformable cover of marine sediments; but this cover may be wholly stripped off while the surface of the plain is still sufficiently preserved for recognition, even though trenched here and there by deep valleys. Plains of subaërial denudation attain their best development in regions of small vertical oscillations about a long maintained average altitude. When more or less perfectly reduced to baselevel, these plains or peneplains may be elevated, and thereupon introduced into a new cycle of denudation; or they may be depressed, submerged, buried under waste from some neighboring land area, and then again elevated with an unconformable cover on their back. In the latter case they will simulate the later history of uplifted plains of marine denudation.

It is notable that in the description of plains of denudation, whether partly exposed, as at the base of a newer formation lying evenly on the denuded surface of an older formation, or completely exposed as in uplifted plateaus, geologists generally assume the correctness of the belief of the school to which they belong, treating the matter as if it had been carried beyond the stage of discussion. Some writers, however, examine the problem more deliberately, and by *a priori* argument ead themselves to belief in one hypothesis or the other. Very few have attempted to settle the problem by *a posteriori* argument, though here, as generally in geological questions, this method is probably safer than the other. It may be noted that the geographical surroundings of the two schools seem to have had something to do with their beliefs. European geologists still occupy the ground where a century ago nearly all topographic forms were ascribed to marine denudation; the English members of the school in particular are always close to the line of breakers that attack their coast, and the production of valleys is about as much as most of them will allow to subaërial agencies. American geologists have worked in a new field. Members of our western surveys have found evidence of vast denudations in regions so remote from the sea that hardly any mention of marine erosion is to be found in their reports; and under their lead, subaërial erosion has come to be considered competent not only to produce valleys, but to widen the valleys so far as to consume the interstream hills and thus reduce a region to almost featureless lowland close to baselevel. I believe it is fair to say that the few Europeans who share more or less fully the belief of the American school, are precisely those who are most conversant with American geology: but this is not a rule that works both ways.

The particular characteristics of the two classes of plains, by which they can be distinguished, may be deduced from a consideration of their processes of origin. Whatever valleys may be eroded in a region will be extinguished as it is planed across by the sea waves: and when it rises with a cover of sediments on its back, a new system of streams will be developed: these streams will be essentially unrelated to the structure of the denuded plain beneath the cover, and when they cut down on it, they will with respect to its structure follow the random habit of superposed streams. But if baseleveling is accomplished by subaërial erosion, the streams will attain a considerable adjustment to the structures on which they work so long; the valleys will mostly follow the weaker strata, and the harder strata will form low divides, crossed only by the chief transverse streams. When the plain is introduced by elevation into a new cycle of erosion, the adjustments will be extended. Streams of so systematic a pattern can easily be distinguished from the random streams that should drain a plain of marine denudation.

If this consideration is valid, it will follow that various plains of denudation where adjusted drainage prevails must be referred to subaërial agencies. There are, however, many examples of plains of denudation to which this test cannot be applied: and it is entirely possible that plains whose drainage is not adjusted to their structure may have been chiefly denuded under the atmosphere, but afterward submerged and buried before being uplifted and dissected.

This paper was discussed by Messrs. Willis, Reid, Hayes, Van Hise, and Gilbert, who gave instances from different parts of the continent illustrating one or the other interpretation cited, or showing the influence of the character of the rocks and of isostatic adjustments.

Cuspate Fore-lands. F. P. GULLIVER, Cambridge, Mass.

1. Action of waves, tides and currents. Waves attack the whole coast, but erode more rapidly on headlands than at bay heads. Tides are less effective agents of transportation along shore on exposed coasts than currents, but they are the important agents in sounds, channels and inlets.

2. Current cusps. Type, Cape Hatteras. The cusp is formed in the dead water between two eddy currents.

3. Tidal cusps. Type, West Point, Puget sound, Washington. Cusp is formed between eddies of in- and out-flowing tides.

4. Delta cusps. Type, Tiber delta, Italy. The mouth of the river forms the point of the cusp, on either side of which the alongshore currents arrange the detritus.

In discussion, Mr. BAILEY WILLIS spoke of other examples in the Puget sound region.

Drainage Modifications and their Interpretation. M. R. CAMPBELL, Washington, D. C. The paper opened with a discussion of the subject of stream modification under the influence of slow elevation or depression of the earth's surface. From this is derived the law of the Migration of Divides which controls, to a greater or less extent, the alignment of all drainage systems. According to this law, divides migrate toward a region of uplift and away from a region of depression. The relations of divides may therefore be significant indicators of upheaval or depression, even when these are comparatively slight. Criteria were given by which these modifications may be recognized and the character of the crustal movement determined.

Next followed a brief description of some of the drainage systems of the Appalachian province, south of the glaciated region, to show that similar modifications of the drainage are of common occurrence, not only in the regions of horizontal rocks, but also in the highly complicated geologic structure of the Appalachian valley. It was shown that some of these changes are recent, whereas some probably date back to the time of the Jura-Trias depression.

The principal object of this paper was to show that the drainage of the Appalachians constitutes a record of Mesozoic and Cenozoic history, and that this record is to the physiographer of equal importance to that contained in the forms sculptured from the surface of the land.

Prof. SHALER, in discussion, noted the relations of the drainage systems of Kentucky, and emphasized the value of the paper in helping to clear away points that were previously obscure.

Mr. GILBERT, in reply to a question concerning the effect of the rotation of the earth in modifying the courses of streams, estimated such effect to be very slight and scarcely capable of detection, if it is at all present.

Some fine Examples of Stream Robbing in the Catskill Mountains. N. H. DARTON, Washington, D. C. The Kaaterskill and Plaaterskill, two creeks flowing eastward into the Hudson river, have cut back through the former divide and tapped off the headwaters of two branches of Schoharie creek, an affluent of the Mohawk river. These examples of stream robbing are particularly fine, and are instructively portrayed on the Kaaterskill topographic sheet of the U. S. Geological Survey.

The streams which have done the robbing had the advantage of very steep declivity, which, with the alternation of hard and soft nearly horizontal beds, enabled them to cut deep gorges rapidly, thus overtaking the Schoharie waters, which flow in a valley of considerable elevation but of very slight declivity. Kaaterskill creek, which has been the more energetic one of the robbers, has cut away a portion of the side of one of these elevated valleys along a distance of a mile, and is rapidly increasing its domain. The gorges head in high waterfalls, strikingly attesting the fast rate of the erosion: and the newness of the gorges below is everywhere apparent.

Proofs of the Rising of the Land around Hudson Bay. ROBERT BELL, Ottawa, Canada. The speaker cited well preserved sea margins and gravel terraces, especially on the eastern coast: lines of driftwood above the highest tides; débris along old shore lines in the woods on the west side at a distance from the highest tides; islands near shore becoming peninsulas within the human period; drying of salt water marshes; the character of the lower parts of streams showing recession of the sea; shoaling of mouths of rivers, and formation of new islands and bars in historic times; other historic evidence; successive growth of marsh plants, bushes, poplars, spruces, etc., as the land rises; beach dwellings and other shore works of the Eskimos now elevated to considerable hights; fresh character of fossil shells, etc., in clays and sands; deep water deposits elevated above the sea level at comparatively recent periods; similar phenomena on the eastern coast of the Labrador peninsula; bones of whales, etc., on elevated ground in Hudson strait; raised terraces and beaches in the northwestern part of Hudson bay; and the general shoaling of the water, extension of shores, and enlargement of islands. The recent rise of many portions of the basin of Hudson bay appears to have taken place at the rate of five feet or more in a century.

Movements of Rocks under Deformation. C. R. VAN HISE, Madison, Wis. This paper, discussing the behavior of rocks when subjected to deforming stresses, is the first in a series of four articles which the author will publish in early issues of the *Journal of Geology.* The later articles will treat of rock folds, cleavage and fissility, and joints and faults.

Three zones are shown to exist in the earth's crust: (1) an outer zone of fracture during rock movements; (2) an inner one of mixed fracture and flowage; and (3) an inmost one of flowage. The effects of pressure on rocks were analyzed. Quick application of pressure may fracture, where if applied slowly it would cause flowage. The possible depth at which cavities may exist exceeds its estimate by Heim (5,000 m.). Mathematical deductions by Prof. Hoskins, of Stanford University, made for this paper, show that, if the walls of a cavity are subjected to three equal stresses at right angles with one another, the cavity will be closed up when the stresses equal two-thirds the ultimate strength of the rock. With a single stress the full crushing pressure is needed. Assuming the strongest rock for these conditions, in order to determine a maximum depth below which cavities must be an impossibility, and taking the specific gravity of the crust at 2.7, from which 1 is subtracted for the water that penetrates all fissures, the calculation gives for the first noted relation of forces 6,670 meters, and for the second 10,000 meters, as the depths where cavities become impossible.

In the discussion, Prof. A. C. LANE compared this investigation with his former paper on the escape of the earth's internal gases; Prof. KEMP referred to its bearing on the origin and possible depth of formation of mineral veins; and Prof. B. K. EMERSON cited the Cambrian gneisses of Massachusetts, in which quartz crystals are flattened out as thin as paper, yet with their optical properties unimpaired.

Mr. J. P. IDDINGS mentioned the interesting experiments of Dr. O. Mügge on ice crystals, as recently reported in the *Neues Jahrbuch*, showing that they shear along gliding planes across the optic axis without altering its direction.

Possible Depth of Mining and Boring. ALFRED C. LANE, Houghton, Mich. From a curve representing the minimum cost of mining at various depths, with figures of the value of various deposits, an idea as to the probable depth of mining is obtained. The two chief factors of cost are the the increased length of time in hoist and the increasing temperature. The escape of compressed air helps to overcome the latter difficulty. Figures were given from the Tamarack and the Calumet and Hecla mines, showing that nearly down to 5,000 feet the increase has been a little less than 1° Fahrenheit for each hundred feet, so that a depth of 10,000 feet can probably be reached there with no great difficulty. One Calumet shaft is now down 4,800 feet vertically, and one Tamarack shaft is started which will not reach the lode until it is down 5,000 feet. [This paper will be published in "The Mining Industry," for 1896.]

In discussion, Prof. SHALER suggested that the very low temperature gradient thus found in the Lake Superior copper mining district may be largely the effect of compressed air. The temperature gradient for the Calumet and Hecla mine recently published by Alexander Agassiz appears to give only 1° F. of increase for each 223.7 feet down to 4,580 feet. To supply this gradient a mean rock temperature at 105 feet of 59° F. is used, whereas the mean annual temperature of that district is about 40°, and approximately this temperature of 40° has been determined at slight depths in other neighboring mines. A mean annual temperature of 59° F. is not met north of Kentucky, and this fact makes corroboration desirable before important inferences are based on these exceptionally low gradients.

Prof. LANE suggested that, as the Wheeling record indicates, the low gradient may be due partly to a rise in the surface temperature since the Glacial period, or may also in part be due to the cooling effect of downward percolating waters. He urged the advantage of an exploratory boring from the bottom of one of the copper mining shafts, which might penetrate to a total depth of nearly 15,000 feet below the surface.

Notes on Glaciers. HARRY FIELDING REID, Baltimore, Md.

1. The request made last year for observations on the advance or retreat of American glaciers has brought but few responses; these, however, show that the Carbon River and North Puyallup glaciers on Mt. Rainier, and the Illicellewaet glacier in the Selkirk mountains, are retreating.

2. If we consider a glacier in equilibrium, the amount of ice flowing through any section in a year must equal the ice added to the glacier above that section in the same time. This, in connection with the fact that there is actual accumulation in the reservoir and melting in the dissipator (the region below the *névé* line), shows that the flow must be greatest in the neighborhood of the *névé* line and must diminish as we ascend or descend the glacier from that region. This law of flow is exact, and it must replace the similar empirical rule of velocity first stated by Desor. It is inferred that the greatest flow in the ice-sheet of the Glacial period must have been near the *névé* line, and that this was probably much nearer to the outer edge of the sheet than to the center of distribution. In general, the velocity will be greatest where the flow is greatest.

3. Consideration of the flow in a glacier of indefinite length resting on a bed of uniform slope leads to the conclusion that with ordinary glaciers the parts near the end must owe some of their motion to pressure from behind. This has been generally believed, but not clearly reasoned out.

4. As a result of this pressure, there must be in the dissipator a motion of the ice away from the bed. In the reservoir, on the contrary, there is a motion toward the bed. We are enabled to draw approximately the lines of flow followed by the ice from the time of its deposition as snow to the time of its melting, and also to show the positions occupied by the successive strata.

5. If we knew the distribution of velocity and of melting, we could calculate the form of the glacier's surface. The vertical or overhanging ends of some Greenland glaciers described by Prof. Chamberlin are due to the large quantity of débris in their lower layers, causing more rapid melting there.

6. Glaciers are rarely in complete equilibrium with their surroundings. The relations establishing the form of the surface bring about a state of unstable equilibrium, and this would lead us to expect the great fluctuations in the extent of glaciers which we actually observe.

[This paper will be published in full in the *Journal of Geology*.]

It was discussed by Profs. G. FREDERICK WRIGHT and R. D. SALISBURY, the latter noting that an upward tendency of the lamination of Greenland glaciers is observable where the border is thin but not where it is thick.

The Relation between Ice-lobes south from the Wisconsin Driftless Area. FRANK LEVERETT, Denmark, Iowa. Instead of a coalescence of ice-lobes from the east and the west sides of the Driftless Area in the drift-covered district to the south there was an invasion and withdrawal of one lobe (the western) before the other reached its culmination. The eastern lobe encroached upon territory previously glaciated by the western, depositing a distinct sheet of drift and forming at its western limits a well-defined morainic ridge. There appears to have been a period of considerable length between the withdrawal of the western lobe and the culmination of the eastern.

Subsequently, however, there was a readvance of the lobe on the west into northeastern Iowa, and this re-advance appears to have been contemporaneous with the nearly complete occupancy of northwestern Illinois by the eastern ice-lobe. It seems not improbable that the ice-lobes were then for a brief period coalescent for a short distance about the south border of the Driftless Area. Evidence of complete coalescence, however, is not decisive so far as yet discovered.

These developments serve to throw light upon the cause for the scarcity of lacustrine deposits in the Driftless Area. They show that there was at most but a brief period in which the southward drainage of the Driftless Area was completely obstructed by the ice-sheet.

By means of maps it was shown that there were probably two centers of chief snow accumulation and glacial outflow,—one, predominant the earlier, being in the area between Hudson bay and the Rocky mountains; and the other, later predominant, on the Laurentide highlands and the Labrador plateau.

Prof. SALISBURY, in discussion, remarked the great complexity of the Glacial period; and Prof. WRIGHT, while admitting its complexity in details, emphasized its essential grand unity.

Prof. SHALER directed attention to the importance of demonstrating the progress of glaciation from west to east, because, if the sequence of events can be established, we thus advance far toward discovering their causes.*

The Loess of western Illinois and southeastern Iowa. FRANK LEVERETT. The north border of the loess both in western Illinois and eastern Iowa appears to have been determined by the ice-sheet. The loess is apparently an apron of silt spread out to the south by water issuing from the ice-sheet. It is loose textured at the north and becomes finer textured toward the south, showing a decrease in the strength of depositing currents. The wide extent of the loess over the uplands has led to a consideration of the influence of wind as well as water in its distribution. It is thought that wind-deposited loess may be distinguished from that which is water-deposited. The wide extent, however, appears to be due to water distribution rather than wind. Wind action appar

*Compare AM. GEOLOGIST, vol. XIV, pp. 62-65, July, 1894; and two articles, with maps showing stages of recession of the ice-sheet, in vol. XV, for May, 1895, and vol. XVI, for August, 1895.

ently came into force subsequent to the water distribution and is of minor importance.

Mr. GILBERT, in discussion, mentioned that in eastern Colorado, along the Missouri Pacific railroad, loess has gathered on the leeward side of sand dunes; and Prof. EMERSON spoke of the aqueous loess deposited by the annual floods of the Connecticut river on the meadows of Hadley, Mass., and of the eolian loess on the neighboring hills.

High-level Terraces of the Middle Ohio and its Tributaries. G. FREDERICK WRIGHT, Oberlin, Ohio. Between Steubenville and Marietta, Ohio, deposits of glacial gravel were observed in various places on the 300-foot rock shelf, as on both sides of the river in the vicinity of Steubenville, and on the West Virginia side at Wellsburgh. This is about twenty miles farther south than such gravel had been observed by Mr. Leverett, at Toronto, Ohio.

Below Wheeling scattered granitic pebbles of small size were found on rock shelves from 200 to 250 feet above the river near Moundsville, New Martinsville, and Sistersville. At New Martinsville they occur in considerable numbers over an area about a half mile long; and one was found a foot in diameter. It is possible that these have all been carried up from the river a mile away; but their distribution would indicate a deposition by natural means. At Sistersville the pebbles seem to have been thrown out from a deposit of river silt 190 feet above the river, in which an excavation had been recently made for an oil tank.

Between St. Mary's, West Virginia, and Newport, Ohio, there is a most singular abandoned channel of the Ohio river, about three miles long, which had been worn down to the level of the present bottom of the river previous to the deposition of the glacial gravel terrace; for both channels were filled up with the gravel to a depth of from 70 to 90 feet, and the abandoned channel has been nearly opened by the small streams entering the Ohio at either end.

At the lower end of the island between the two channels, there is a deposit of sand 200 feet above the river and extending a half mile or more in its lee. This has an irregular surface near its upper end, and is several hundred feet wide. It could have been formed only when the water was flowing at that level. It seems improbable, if not impossible, that such a deposit has retained its elevated position during all the period required for the Ohio to erode its rocky bed from that level to its present bottom. It is, therefore, one of the many residual phenomena which point to some such temporary flooding of the middle Ohio valley as would have been produced by the Cincinnati ice-dam. Its explanation will probably be similar to that of the accumulation of silt in Teazes valley, West Virginia, which is at nearly the same elevation.

In discussion, Prof. I. C. WHITE attributed the island in large part to a preglacial channel of Middle Island creek, which debouches into the Ohio valley at St. Mary's, directly athwart its course and through a gorge that is continued in the abandoned channel now forming the island's northwest side. He also stated that pebbles often are found at exceptional hights on the hills because the farmers use sand with some contained gravel for bedding in their stables and consequently scatter it over their fields at all altitudes.

Prof. SHALER also cited the custom among the Indians of cooking with heated boulders, and as the local limestones and sandstones were of no value for this purpose they often brought granitic boulders from a distance. In answer to these suggestions, Prof. WRIGHT cited boulders of two tons' weight, which manifestly could not be explained in such ways.

Prof. ANGELO HEILPRIN then mentioned certain polished and grooved rocks of South Africa which had been regarded as glaciated. Investigation, however, has shown that the polishing is due to the habit of elephants, formerly abundant there, to resort to them and roll and scrape on them, and that the grooves are due to the rubbing of their tusks.*

Mr. LEVERETT corroborated the observations of Prof. Wright in the northern part of the area.

Four great Kame Areas of western New York. H. L. FAIRCHILD, Rochester, N. Y. This paper, read only in abstract, described four massive deposits of waterlaid drift, of mound and basin topography, with peculiar features of altitude and relation. One of the areas lies south of Sodus bay, between Lyons and Geneva, and is called the Junius area. It is some miles in extent, holding several small lakes, and forms the highest ground upon the meridian between lake Ontario and the Devonian plateau enclosing the "Finger lakes." The three other areas are south of Irondequoit bay. One occupies the valley of the Irondequoit creek, and lies partly below the level of the glacial lake Iroquois. Another is the Mendon area, which, with the Irondequoit area, was mentioned in the AMERICAN GEOLOGIST for last July (vol. XVI, pp. 49, 50). Lastly, the Victor area lies contiguous to the Irondequoit, southward, and is the most massive and elevated of them all, rising to 1,100 feet above the sea, and being the highest point in western New York north of the Devonian plateau.

Erosion planes of the glacial lake Warren are evident upon these areas, the upper one being considerably under 900 feet.

The paper described these very massive kame deposits in detail, with maps and photographs, and discussed the problems of their formation and of the upward transportation of boulders and smaller cobbles and pebbles to hights some hundreds of feet above their parent ledges not many miles distant. [It is to be published in the next number of the *Journal of Geology.*]

*Similarly, in western Minnesota and northwestward, boulders are often found having their edges and corners smoothly polished by the rubbing of buffaloes, which twenty to fifty years ago roamed there in countless herds, but now are almost exterminated. (Geology of Minnesota, vol. II, 1888, p. 516.)

Preglacial and Postglacial Valleys of the Cuyahoga and Rocky rivers. WARREN UPHAM, St. Paul, Minn. (Read by title.) The Cuyahoga river, entering lake Erie at the city of Cleveland, occupies the same valley as before the ice age, but the rock bed of the preglacial river is more than 200 feet below the present river and level of the lake. About eight miles farther west the mouth of the postglacial channel of Rocky river, eroded nearly 100 feet deep in the Erie shale, is three-fourths of a mile east of the drift-filled preglacial valley, in which a very interesting section of two deposits of till, with intervening stratified sand and fine silt, is seen along a distance of one mile of the lake shore. The glacial and stratified drift deposited in both these preglacial valleys give evidence of a recession and re-advance of the ice-sheet during its general stage of formation of the numerous retreatal moraines of the district.

Four shore lines, the highest belonging to the Western Erie glacial lake and the lower ones to the ensuing lake Warren, are described in detail in their course through Cleveland, crossing the Cuyahoga valley. The highest or Leipsic beach is traced several miles farther east than it was before known, and is thus found to be correlative with the marginal moraine which extends from Euclid eastward closely parallel with the lake shore.

In the closing part of this paper, the glacial re-advance shown by the Rocky river and Cleveland sections is compared with the glacial and interglacial deposits of Toronto and Scarboro', Ontario, which were latest and most fully described by Prof. A. P. Coleman in the last Sept.-Oct. number of the *Journal of Geology*, (vol. III, pp. 622-645, with sections). Mr. Upham attributes the fluctuations of glaciation which are thus recorded on the north side of lake Ontario to a time after the formation of the moraines, stratified drift, and upper till, in the vicinity of Cleveland.

After the deposition of the fossiliferous sand and clay beds of the Scarboro' section, an outflow east from the Ontario basin at Rome began. On account of the depression of the land which brought on this final Champlain epoch of the Ice age, the relative hight of the land in the vicinity of Toronto, as compared with the depressed region about 190 miles eastward at Rome, then permitted a stream to erode its valley near Toronto to a depth below the present level of lake Ontario. Later, and after a temporary advance and second retreat of the ice border at Scarboro' and Toronto, forming a thick till deposit, the differential re-elevation of the land, probably 200 to 300 feet more at Rome than in the west part of the Ontario basin, caused the water level of lake Iroquois to rise gradually on the land westward until it stood at last permanently during many years at the conspicuously developed Iroquois beach.

The uppermost till of the Scarboro' Heights, that is, the second till deposit above the fossiliferous beds, seems to be a retreatal moraine, belonging to the second glacial recession, or to a third retreat after a second slight re-advance, all considerably antedating the Iroquois beach, which lies above all these drift accumulations.

Paleozoic Terranes in the Connecticut Valley. C. H. HITCHCOCK, Hanover, N. H. As opportunity has been afforded since the termina tion of the New Hampshire survey in 1878, the author has further investigated the geology of portions of the upper Connecticut valley, and desires to put on record a few important conclusions.

1. Re-arrangement of argillites. One series seems to underlie and the other to overlie the Calciferous mica schist. Granting that the hydro-mica schists join the corresponding developments on the east flank of the Green mountains, we have the following synclinal succession: (a) underlying gneiss: (b) hydro-mica series; (c) lower argillite: (d) Calciferous mica schist. This lower argillite has not been noticed south of Barnard and Hartland, Vt. One band has been extensively quarried for roofing slate at Northfield, and it passes into Canada along lake Memphremagog. The other argillite combines a part of the Cambrian clay slate of the New Hampshire report with the Coös slates, which contain delicate staurolites and garnets. Thus combined, this argillite may be traced almost continuously from Massachusetts to Dalton, N. H.

2. The hornblende schists near Hanover, N. H., are disposed in masses allied to laccolites. The principal area is ten miles long, with very distinct planes of foliation uniformly tilted northwesterly at an angle of fifty degrees. On the west side, this band comes successively in contact with mica schist, hydro-mica schist, a band of argillite, and chlorite schist; and in every case it has altered the adjacent rock through its heat. On the east side it universally adjoins mica schist where the alterations are less apparent but still visible. Thus this hornblende schist behaves exactly like a true igneous ejection. The presence of abundant foliated planes must therefore have been due to pressure and flow occasioned by the tendency of the paste to work upwards against the cap which has now been denuded.

3. The protogene gneiss areas of Hanover and Lebanon, N. H., and at the southwest end of the Bethlehem area, are known to be eruptive, because both of them contain inclusions of the adjacent mica schists. This gneiss was called Laurentian in the report, with the approval of both Prof. J. D. Dana and Dr. T. Sterry Hunt.

4. The removal to the igneous category of the foliated hornblende schists, diorites, diabases, and two sorts of protogene, all of which had been classed as Huronian, will afford the opportunity to revise the arrangement of numerous schists in Littleton and Lisbon, N. H., where characteristic Niagara fossils may serve as our guide to identification of age. The slates of Blueberry mountain seem to maintain a synclinal attitude, overlying the Niagara. A rather nondescript assemblage of schists, hesitatingly called the Swiftwater series in the report, may play an important part in the re-arrangement.

5. It is worthy of note that the Canadian geologists call the Calciferous mica schist group after it passes the international boundary Cambro-Silurian, because of the presence in the terrane of Trenton graptolites, after Lapworth. Some Upper Silurian fossils, more or less connected with these limestones, are conceived to be remnants of a superior band, now almost entirely removed by denudation, and not characterizing the age of the calcareous floor. They also regard as

Cambrian and Pre-Cambrian the rocks referred to the Huronian in the New Hampshire report.

Prof. EMERSON, in discussion, remarked that this revision places the geological structure in harmony with the results now attained in Massachusetts on the south.

The Devonian formations of the southern Appalachians. C. WILLARD HAYES. Washington, D. C. A generalized section of the Devonian series in the southeastern United States was described. It has an upper and very persistent layer, only 8 to 24 inches thick, which is a green sandstone, with phosphatic nodules and shreds of volcanic glass, feldspars, etc., such as to indicate a volcanic tuff. Below this comes black shale, ranging up to 12 feet in thickness, but not always present. The next and basal stratum is a ferruginous sandstone or conglomerate, up to 6 feet thick, but sometimes absent, which contains the recently discovered phosphate beds of Tennessee. Various attempts have been made to explain the surprising thinness or actual absence of the Devonian formations over great areas, as follows: (1) the region was a deep sea bottom, lacking sediments; (2) it was a region of shallow waters whose entering streams were without sediments; (3) it was a land area: (4) it was a shallow sea without sediments and with swift but clear currents, like the Gulf Stream region of the West Indies. The speaker believes that such scanty sediments as were distributed came in large part in currents from the northeast, and that another current came from the southeast and flowed around the Cincinnati arch.

This paper was discussed by Messrs. LANGDON, STEVENSON, KEITH, VAN HISE, and H. S. WILLIAMS, especial attention being directed to the relations of the Devonian to the Helderberg limestones in southwestern Virginia.

Notes on the Relations of the Lower Members of the Coastal Plain series in South Carlina. N. H. DARTON, Washington, D. C. Until about a year ago the geology of South Carolina was known principally from the work of Tuomey over fifty years ago. He determined the relations of many of the formations of the Coastal Plain area, but several very important features were not ascertained. It is now found that the strata classified by Tuomey as the basal members of the Eocene are instead of Potomac age, and that this formation extends northward beneath the marine Cretaceous marls, of which the edge emerges from under the Eocene north of the Wateree river. As was suggested by McGee several years ago, a continuous sheet of the Potomac formation lies on the crystalline rocks across South Carolina.

The entire Coastal Plain series in this state comprises the following formations, in their descending order: Columbia gray sands; Lafayette orange-colored loams; Miocene sands and marls; Eocene marls above and buhrstone below; Cretaceous marine marls, sands, and clays; and the Lower Cretaceous or Jurassic non-marine Potomac sands, sandstones, kaolinic arkose, and clays, in which plant remains were observed at many places. In a deep well at Aiken the full thickness of the

Potomac beds was exhibited, the section being Lafayette reddish clay, 45 feet; the Potomac formation, consisting successively of sand, 55 feet, "chalk" (a mixture of fine white sand and kaolin), 30 feet, and sand and soft sandstone, with some clay, 335 feet, reaching to a total depth of 465 feet, where the boring passed into granite. In a deep well at Florence, the Newark sandstone was reached, far south of its previously known areas.

Résumé of general stratigraphic relations in the Atlantic coastal plain from New Jersey to South Carolina. N. H. DARTON. A series of five cross sections was displayed, illustrating the larger stratigraphic features. Deep well borings at many points have been the most important sources of new information, and of these Mr. Darton has made a special study for a report now in course of publication. His field studies in South Carolina, described in the previous paper, indicate some of the relations of the lower Coastal Plain formations where formerly there was much obscurity; and the recent investigations by Dr. W. B. Clark have added much to knowledge of the Upper Cretaceous in New Jersey and eastern Maryland.

The relationship of the Potomac, marine Cretaceous, and Eocene formations in South Carolina is due to an overlap of the Eocene southward beyond the edge of the marine Cretaceous strata. The Cretaceous marl and clay marl series of New Jersey has been so uplifted and eroded in post-Cretaceous times that in the present outcrops its upper members drop out one by one in its extension into Maryland, and only the lowest member reaches the surface in the latitude of Washington. The series is overlain by the Miocene to the westward, notably in central southern New Jersey and opposite to Washington; but in the greater part of the Maryland region, and apparently also in southeastern New Jersey (as shown by well borings), it is overlain by the Pamunkey formation (Eocene).

The Magothy formation, although a thin and very arenaceous member of the Coastal Plain series, has been found to be widespread in eastern Maryland, and to extend far northward into New Jersey, where it appears to be represented by water-bearing gravels and sands that are revealed by many well borings in the western side of the southern portion of the state. It lies between the Raritan (Potomac) clays and the base of the clay marls or Matawan formation of Dr. Clark.

Abundant new data have been received, mainly from well borings, bearing on the thickness, character, and extent of the Chesapeake (Miocene) formation in Virginia, Maryland, Delaware, and New Jersey.

The Natchez formation. T. C. CHAMBERLIN, Chicago, Ill. (Read by title.) Alternating stages of deposition and erosion of the Pleistocene stratified gravel, sand, and fine silt of the immediate valley of the Mississippi river in the vicinity of Natchez, Mississippi, are described from observations during the year 1895, with examination of well exposed sections. The Natchez formation and associated deposits and stages of erosion are of especial interest on account of their probable relationship with the Kansan, Aftonian, and Iowan stages of the Glacial period in the upper and more northern part of the Mississippi basin.

Some Stages of Appalachian Erosion. ARTHUR KEITH, Washington, D. C. This paper gave a general review of the drainage systems of the Appalachian area, and of the agencies which contributed to develop the present topography. It especially described the typical forms of erosion in that region and the grouping of the more and the less matured forms in relation to the main divides of the river systems, thus defining the normal sequence of degradation forms.

The Tennessee river system was analyzed, and four main stages of reduction to baselevel were described, each peneplain being lower and smaller than the preceding, and each nearly level in the main valleys and gradually rising toward their peripheries. As each stream and branch diminishes, the forms of erosion rise in a concave curve through baseleveled plain, peneplain, valley, terrace, bottomland, planation slope, and gorge, to the residual mass. The omnipresence of this relation defines it as the law, and the uniformity of level in each well developed peneplain is its characteristic present feature.

Similar features were cited as characterizing other river basins, so that the number of distinct stages of erosion is at least seven.

Attention was called to the warping of peneplains in certain regions, and to its comparative rarity and localization as furnishing the exception to the usual uniformity of level. Certain peneplains, described by other authors as deformed or warped, were found to be not deformed but following the sequence of erosion forms and the normal slopes, even in a direction contrary to their theory. Their error was ascribed to the correlation of portions of different peneplains into one surface. Two peneplains with strongly warped surfaces thus were made to appear instead of four or more whose surfaces are only locally warped.

EDITORIAL COMMENT.

THE JAMES HALL MEDALS.

The man of science whose accomplishments have received substantial recognition from various dignitaries and learned bodies of the world is seldom aroused to the fact that while the honor achieved is his the possibility of attaining it may have rested with others. Hence it is that due acknowledgment of coöperation in such achievements is still a matter of gratified, if surprised, comment. Not every such highly distinguished man can, even if he would, turn to his advisers and supporters with substantial public recognition of such contributory obligation; such avowals, even when possible, are too frequently altogether withheld, involving no added honor to the principal and always a distinct and positive deprivation to the accessory. But when the recipient of many largesses is not only disposed, but is also able to perpetuate in everlasting brass the services of those whose succor came when needed most and to whom the science thus owes a genuine debt, the graceful act will receive the applause it merits. Hence it gives us pleasure to refer to the fact that Prof. James Hall, who has probably been more signally decorated than any other living geologist, has commemorated in gold the services of some of the men who have enabled him to carry on his official work in the state of New York. Of several gold medals which he has had struck for this end, the first was given to Jacob A. Cantor, a member of the state senate, through whose efforts Prof. Hall was recommissioned by the Governor in 1893. The second is in memory of James W. Husted who during twenty years of service in the legislature of New York was a staunch friend of Prof. Hall and his work. This medal was presented to the son, James W. Husted. A third has been given to Mrs. George Huntington Williams in memory of her father, the Hon. Daniel P. Wood, an enthusiastic promoter of geological science in New York during his long connection with the legislature of the state; and a fourth to Danforth E. Ainsworth in recognition of earnest and practical coöperation in the achievements of later years. *Non facit ea quae juvenes, at vero majora et meliora facit.*

The Gold Fever in South Africa.

The discovery of the gold field of the Transvaal in South Africa bids fair to surpass in its results everything of the kind that the world has ever seen, throwing even the historic Californian and Victorian treasures into the shade. Johannesburg, the chief center of the region, has grown from an open desolate prairie ten years ago to a solid city of 100,000 people with all the most modern appliances and conveniences, and luxuries of the highest civilization. The Witwatersrand is sending gold into the markets of the world as it never was sent in before and will probably supply all that is needed to meet the increasing demand for the precious metal in coinage. The world's yield of gold, which rose from about $60,000,000 a year to about $120,000,000 on the discovery of the Victorian and Californian deposits, again sank until in 1890 it was about $100,000,000. But by 1893 the South African mines had raised it to about $150,000,000, and the estimate for the present year is $200,000,000, or nearly twice as great as was ever known before they were discovered.

The geology of South Africa may be outlined as follows:

d. Recent deposits of alluvial and of æolian origin, consisting largely of "laterite" or brick-earth.

c. Karoo formation, of the date of the lower Mesozoic of Europe and found chiefly in the Cape Colony, Natal, South Transvaal and Orange Free State. In this occur the coals of the region which supply the fuel for the gold mines.

b. Cape formation. Shales, sandstones, conglomerates and limestones in the southwest and Mid-Transvaal. Here lie the auriferous beds. The metal is found in the matrix of the conglomerate, but not in the pebbles. The yield is not very high, averaging last year thirteen pennyweights per ton of sandstone. The beds have been worked to the depth of 1,000 feet. 2,000 stamps are already at work crushing four tons a day each and obtaining about half an ounce of gold from the ton.

a. Granites, schists and gneisses of Central Africa, Mashonaland, Matabeleland, Mozambique, etc.

The minute geology of the gold field is as yet unknown, but, as a geological society has already been established at Johannesburg with more than 300 members, we may hope soon to have full details of the structure of the country and the probable origin of the auriferous sand.

Great excitement has naturally prevailed in the mining stock market in consequence of this unparalleled product of gold. Fortunes have changed hands. The English papers are full of glowing advertisements of the mines of the Witwatersrand and speculation is rife, as might be expected. Much of this is based on "airy nothings" and will collapse, but a solid substratum remains, as may be seen from the facts given above, and the stability and progress of Johannesburg and its gold field are as well assured as were those of California and Victoria.

E. W. C.

Notice Concerning the Geological Map of Europe Published under the auspices of the International Congress of Geologists.

At the third session of the International Congress of Geologists, held in Berlin in 1885, the committee on a geological map of Europe made a report in which the following conditions of publication were announced. (Berlin volume, page LXII.) "The house of Reimer & Co. undertakes the publication at its own expense on the sole condition that the international committee guarantee the sale of 900 copies at 100 francs per copy, and furnish the sum in advance.

"The subscription price of 100 francs will be augmented to 125 francs in the regular book trade.

"The committee has divided this guarantee subscription as follows. Each one of the large countries of Europe (to wit Great Britain, France, Spain, Italy, Austro-Hungary, Germany, Scandinavia, and Russia) agrees to take 100 copies. The six small countries (i. e. Belgium, Holland, Denmark, Switzerland, Portugal and Roumania) will divide among them the remaining 100 copies." etc., etc.

In the fourth session of the Congress held in London in 1888 the following note occurs in the report of the proceedings of the committee on the geological map of Europe. (London volume, page 59.)

"The American committee requested of the Directory to be admitted as a subscriber to the map of Europe on the same terms as the great countries of Europe (sic) i. e. for at least one hundred copies and at the same price."

Dr. Frazer the secretary of the American committee obtained the names of American subscribers to the "one hundred copies at the same price" (100 francs), within a short time of the granting of this request and promptly notified the publication committee in Berlin, Messrs. Beyrich and Hauchecorne, of the fact.

As it appears however the map is being offered for sale in the German catalogues at the price mentioned in the Berlin resolution as that accorded to original subscribers.

On this account the undersigned advises the survivors of those who so patriotically came forward in 1888 to enable the geologists of the United States to enjoy the same privileges as those of the great countries of Europe, to send through their own agents for this geological map of Europe since there would no longer be any advantage in obtaining them through a single channel commensurate with the delay and trouble which would be occasioned. Those subscribers who are known to have died are added in parentheses. PERSIFOR FRAZER.

List of Subscribers to the Geological Map of Europe in the order of their subscriptions.

NAME.	NUMBER OF COPIES.	
Williams College	1	
Ohio State Univ., Columbus	1	
Rensselaer Polytechnic Institute	1	
University of Virginia	1	
Am. Inst. of Mining Engineers	1	
Amherst College	1	
Cornell University Library	1	
Provincial Museum, Halifax	1	
Wesleyan University, Middletown, Conn	1	
Lehigh University, Bethlehem, Pa	1	
Academy of Natural Sciences, Philadelphia	1	
Univ. of California, Berkeley, Cal	1	
Prof. C. H. Hitchcock, for Dartmouth College	1	
Prof. J. S. Newberry, (dead)	1	
Indiana University	1	
Smith College, Northampton, Mass	1	
U. S. Geological Survey, Washington, D. C	3	
Rutgers College, New Brunswick, N. J	1	
Yale University Library	1	
American Geographical Society	1	
Peter Redpath Museum, McGill College, Montreal	1	
U. S. Military Academy, West Point, N. Y	1	
Prof. G. A. König	1	25
N. Y. State Library, Capitol, Albany	2	
Eckley B. Coxe, Drifton, Pa., (dead)	2	
University of Nebraska	1	
Kansas State Library	1	
B. S. Lyman	1	
Johns Hopkins University	1	
F. W. Matthiesen, LaSalle, Ill	1	
Lehigh Valley R. R. Co., Philadelphia	1	
E. V. d'Invilliers, Philadelphia	1	
University of Wisconsin, Madison	1	
Second Geological Survey of Pennsylvania	2	
State Mining Bureau of California	1	
Washington University	1	
Dr. R. W. Raymond	1	

Franklin Institute, Philadelphia.. 1
Harvard College Library.. 1
University of North Carolina, Chapel Hill............................ 1
University of the City of New York.................................... 1
Massachusetts Agrl. College, Amherst................................. 1
W. S. Keyes, San Francisco, Cal.. 1
R. D. Baker, Philadelphia 2 50
S. F. Emmons, U. S. Geological Survey, Washington, D. C.... 1
H. N. Sims, Shenandoah, Page Co., Va................................ 1
American Museum of Natural History, N. Y......................... 1
Prof. Alexander Winchell, Univ. of Mich., Ann Arbor, (dead)... 1
H. Huber, Argentine. Kansas... 1
Jas. E. Mills, E. Quincy, Cal... 1
Cooper Union, N. Y... 1
Collegiate and Polytechnic Institute, Brooklyn..................... 1
Cornell University, N. Y.. 1
Joseph D. Potts, Philadelphia, (dead)................................ 1
Prof. J. C. Fales, Danville, Ky., Centre College.................. 1
T. H. Aldrich, Blocton, Ala... 1
Chas. Paine, Pittsburg... 1
Colorado School of Mines, Golden, Col............................... 1
Western Reserve Univ. (d. E. W. Morley), Cleveland, Ohio..... 1
F. Klepetko, Houghton, Michigan....................................... 1
Thos. Macfarlane, Ottawa, Canada..................................... 1
Arkansas Geological Survey, Little Rock.............................. 1
Buchtel College. Akron, Ohio.. 1
Mercantile Library, Philadelphia.. 1
University of Michigan, Ann Arbor..................................... 1
Alabama Geological Survey, University of Alabama............... 1
E. S. Whelen. Philadelphia. (dead)..................................... 1
Worcester Polytechnic Institute... 1
Julius Bien, N. Y.. 1 75
W. A. Ingham.. 1
Dr. Jas. P. Kimball, 109 East 15th St., New York City?........ 1
Dr. J. S. Newberry, N. Y., Dec. 29, '87, (second copy?)......... 1
New Harmony Institution, Ind... 1
R. Ellsworth Call, Louisville, Ky... 1
Boston Soc. Nat. Hist 1
Hastings, Jno. B., Ketchum, Alturas Co., Idaho................... 1
Geological Survey of Minnesota, Minneapolis....................... 1
Lacoe, R. D., Pittston, Luzerne Co., Penna......................... 1
Vassar College, Poughkeepsie, N. Y................................... 1
Mt. Holyoke Seminary, South Hadley, Mass......................... 1
Colby University, Waterville, Me.. 1
Cincinnati Soc. of Nat. History 1
Packer Collegiate Institution, Brooklyn, N. Y....................... 1
Emmens, Stephen H., Harrison, N. Y................................... 1
School of Mines, Rapid City, South Dakota 1

Ohio University, Athens, O., Prof. A. D. Merrill	1	
Proctor, John R., Franklin, Ky., Aug. 19, '88	1	
Rose Polytechnic School, Terre Haute, Ind., Aug. 19, '88	1	
Read, Jas. P., Calico, San Bernard Co., Cal., Aug. 31, '88	1	
Oberlin College, Ohio, Aug. 23, '88	1	
Frazer, Dr. Persifor, Philadelphia	1	
Streater Township High School, La Salle Co., Ill. R. William Price, Sept. 21, '88	1	
State Univ., Athens, Ga., Prof. J. W. Spencer, Nov. 12, 1888	1	
Lowry, Thos., Minneapolis, Minn., Nov. 13, 1888. (N. H. Winchell), Nov. 13	1	100

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Ueber die Graptoliten; Inaugural-dissertation. By CARL WIMAN. (Bull. Geol. Inst. Upsala, no. 4, vol. II, pt. 2, pp. 1-74, pls. 9-15, 1895). The revival of interest in the study of the graptolites has been largely due to the application of refined preparative methods to the isolation of the colonies and the microscopic analysis of their structure. Wiman's paper is somewhat general in scope and brings out many important points in the morphology and histology of certain genera, e. g., *Climacograptus*, *Retiolites* and *Dictyonema*, yet we conceive that its most attractive portion to the paleontologist may prove to be that in which the author details the technique of his preparative treatment of these delicate fossils. So full of suggestive hints is this part of the paper to all who interest themselves in seeking the clew to nature's best work among the fossils that we present these experiments without much abridgement.

Gümbel, Holm and Törnquist have isolated the graptolites by various methods, either dissolving them from a calcareous matrix with acid or with the help of Schultze's medium, which is a solution of calcium chlorate in nitric acid. The treatment of the specimen varies with the nature of the matrix. Sweden has furnished many instances of graptolites preserved in limestone, in contradistinction to America where such a mode of preservation is not frequent. The handling of such material, if the matrix is comparatively pure, is simple. If the solution is to be conducted on a moderately large scale, commercial muriatic acid is used, but as even the ebullition of the gas, if violent, may break the delicate fronds, it is often requisite to use caution either by dilution of the acid or by the use of a milder solvent, such as acetic acid. Crude muriatic acid contains more or less sulphuric acid which in reaction with the limestone produces gypsum and this is likely to crystallize about the fronds unless the process be arrested or the solution decanted before such crystallization sets in. With the close of the process most of the delicate fronds will have dropped into the muddy residuum and their extraction will require careful manipulation.

Decanting must be done with caution and through a fine wire or muslin net as some fronds will be found floating on the solution. The mud is to be similarly handled, taken up with a spatula and placed upon a fine netting, and then horizontally lowered into a vessel of water. The mud will fall through and all fossils smaller than the mesh remain behind. The handling of this "pay dirt" with spoon and metallic net would be rather too rough for some delicate fossils. For example, a minute *Productus* with its hair-like spines would hardly come through intact and larval bodies smaller than the mesh would be lost. The writer may suggest that a more gentle and surer process is to elevate a small portion of the dirt upon a softened blotting paper, transfer it to clear water in a shallow porcelain or japanned developing tray, where each fossil, however delicate, may be picked up on the end of a camel's hair brush with a pointed bit of blotting paper for a pusher.

Wiman finds that highly aluminous clay slates are the most difficult matrix to manipulate. With the use of hydrofluoric acid a crust of some fluosilicate is formed about the fossil. "Hence I have treated this kind of rock first with acetic acid and then with hydrofluoric acid. When subjected to acetic acid whatever lime is present is dissolved without the fragment losing its form. This process may last for even very small fragments for several weeks and must be allowed to continue until one is convinced that the lime is all out and the rock throughout of a loose consistence. Afterwards the material should be washed for several days in water until all lime-salts are removed, and then treated with hydrofluoric acid which will soon set the graptolite free." We have secured similar results with clay slates having a considerable content of lime by the use of pure caustic potash after treatment with acid, washing and thorough drying. The real difficulty, however, is to isolate fossils of any kind from a clay slate in which the lime content is so little that its loss produces no palpable difference in the consistence of the rock. This is the nature of most of the graptolite-bearing rocks of America and the winning of the fossils from them is yet to be accomplished.

In treating chert masses the author has set free the graptolites by the use of hydrofluoric acid, "acidum hydrofluoricum concentratissimum fumans 55 per cent.," more or less diluted with water. The solution is made in a shell of platinum or lead. The process must be interrupted now and then as crystals of some fluosilicate will be deposited on some of the exposed parts of the graptolites and load them until they break. The rock must then be transferred to another vessel and treated for a few days with muriatic acid which will dissolve the salt. Then the piece may again be treated with the fluoric acid. To reduce in this way a piece of chert a half the size of one's fist takes from one to three weeks." To decolor the graptolite skeletons for microscopic study the author has used Schultze's medium (strong nitric acid with crystals of calcium chlorate), but finds it too harsh. With better results he has employed *eau de Javelle* (calcium hypochlorite) and after washing, treating with alcohol, clearing with turpentine, chloroform or toluol and mounting in Canada balsam.

Some other elaborate technical methods were used, adapted to the nature of the subjects treated and in preparation for the microtome.

In his contribution to the morphology of the graptolites the author propounds a classification, recognizing three main divisions or groups, viz.: Graptoloidea Lapworth, Retioloidea Lapw. (*Retiolites*) and Dendroidea Nicholson (*Dictyonema*, *Dendrograptus*).

Upon the systematic position of the graptolites the following observations are made: "There are three views which are especially entitled to consideration. One is that the graptolites can not be placed in any of the groups of existing animals, and in this opinion I unconditionally concur.

"The second view places the graptolites among the hydroids. No hydroid is known which is constructed like a graptolite, and the individuals of the first order in the graptolite are bilaterally symmetrical, while the corresponding individuals of the hydroids possess a higher grade of symmetry. * * * *

"The third theory connects the graptolites with *Rhabdopleura*. * * The chitin skeleton of the latter has no further similarity to that of a graptolite than that it belongs to a colony-forming animal and that the individuals are covered with concentric growth-lines."

It would seem impossible with present knowledge to assign them a place in the system with existing animals.

As an addendum to his observations the author presents, translated into German, the entire paper by Ruedemann on the Growth and Development of the Graptolite genus Diplograptus, recently published in the *American Journal of Science*, characterizing it as "one of the happiest, perhaps the most interesting of all discoveries among the graptolites." Dr. Ruedemann's remarkable observations will be published at length and fully illustrated in the fourteenth annual report of the state geologist of New York. J. M. C.

United States Geological Survey, Report of the Director, for the Fiscal Year ending June 30, 1895. CHARLES D. WALCOTT. (Extract from the Sixteenth Annual Report, for 1894-'95; 130 pages, with a map showing condition and progress of topographic surveys.) The appropriations for the national geological survey during the year reported were $497,990. The amount allotted for topographic work was $159,200: for geologic work, $113,700; for paleontologic work, $14,000; chemical work, $10,000; gauging water supply, $12,500; preparation of illustrations, $13,000; report on mineral resources, $15,000; purchase of books and distribution of documents, $2,000; engraving and printing maps, $65,000; rent, $14,200; for skilled laborers, etc., $13,000; for the engraving, printing, and binding of the annual report, monographs, and bulletins, $35,000; and for salaries of the director, chief clerk, librarian, and others (thirty in all, employed in the chief administrative department), $31,390. Geologic field work and investigations were in progress under twenty-seven heads of parties, to whom $100,900 were apportioned in sums ranging from $600 to $8,000 for each.

The various fields of work and objects of special exploration by each party are briefly stated, as are also the several researches in paleontology, chemistry, and hydrography. A summary of the mineral industries, with tables giving the quantities and values of their products in 1894, by Dr. David T. Day, occupies eleven pages.

The topographic surveys during the fiscal year covered 7,000 square miles in the Atlantic section, completing seventeen atlas sheets. In the Central section an aggregate area of 10,475 square miles has been surveyed, completing ten sheets. In the Rocky Mountain section, 5,963 square miles were surveyed, completing eight sheets. Lastly, in the Pacific section the area surveyed this year was 6,975 square miles, completing fifteen sheets. The largest area surveyed in any State was in Nebraska, 4,750 square miles; and the total area was 30,395 square miles. About three-fourths of the whole are mapped on the scale of 1:125,000, or about two miles to an inch; and the other fourth is on the scale of 1:62,500, or very slightly less than a mile to an inch. During the field season 120 men were employed in this department, and an average of 65 during the winter. Up to the end of last June, about 900 topographic atlas sheets had been engraved.

Fourteen folios of the geologic atlas of the United States were ready for distribution and sale (at 25 cents a folio, with one exception) June 30, 1895; and six others were in press. The uniform scale of two miles to an inch, except in special cases, is adopted for the entire geologic atlas, including large districts which were surveyed and topographically mapped on the scale of a mile to the inch. W. U.

The Preglacial Valleys of the Mississippi and its Tributaries. By Frank Leverett. (Jour. of Geol., vol. 3, pp. 740-763, Oct.-Nov., 1895.) In this paper Mr. Leverett has sought to bring together such data as are available on the subject of preglacial drainage lines in the northern part of the Mississippi basin. He traces the line of the great river south from its junction with the Minnesota, pointing out the places where its pre- and post-glacial channels do not coincide. In like manner the courses of the Rock river, the Wabash and the Ohio are followed. The help of borings is brought in to show the great depth of the rock bottom of some of these preglacial valleys. The question of a preglacial southward outlet from lake Michigan is discussed, but left undetermined for want of sufficient data. The date of the uplift which led to this deep erosion in preglacial time is considered to be post-Cretaceous. E. W. C.

On the Correlation of New York Moraines with the Raised Beaches of Lake Erie. By Frank Leverett. (Am. Jour. Sci., 3, vol. 50, pp. 1-20, July, 1895.) This paper is a continuation of a previous discussion (op. cit., April, 1892) of the same subject. Mr. Leverett continues his study of the connection between the raised beaches at the western end of lake Erie with the several moraines at its eastern end. He thus connects the "Sheridan" and the "Crittenden" beaches with two well marked moraines into which he thinks they graduate. E. W. C.

Soils of Illinois. By FRANK LEVERETT. (Final Rept. Ill. Board of World's Fair Com., pp. 77-92, 1 map, 1895.) In this paper the author reports his observations on the soils, especially those dependent on glacial action, in the state of Illinois. He classifies them as (1) residuary, from the decay of the underlying rocks and therefore extramorainic, (2) glacial clays, (3) gravelly washes, (4) glacial drainage sands, (5) loess or pervious silts, (6 and 7) silts slightly pervious to water, (8) peat and marl. A short glacial history of the state follows showing how, in the author's opinion, each of these soils was formed.

E. W. C.

Paleontologische Notizen 1 und 2. By CARL WIMAN. (Bull. Geol. Inst. Upsala, no. 3, vol. II, 1895.)

1. *Ein präkambrisches Fossil.* The minute egg-shaped bodies in question have been known to Swedish geologists for some years, from the Visingsö group of pre-Cambrian slates on lake Vettern. The author has analyzed them closely and finds them to be spherical chitinous sacks with a very thin and simple wall. No clew to the real nature of the bodies reveals itself, but the possibility of their being eggs of trilobites is suggested.

2. *Conularia loculata.* An interesting new structural feature for this genus is here brought out. The segmental lines which symmetrically and vertically divide each face of the shell are shown to represent internal erect lamellæ which bifurcate on their inner edges and, though not coming into contact with one another, divide the inner shell cavity into elongated compartments. This structure emphasizes the already recognized differences between *Conularia* and the pteropods.

J. M. C.

RECENT PUBLICATIONS.

I. Government and State Reports.

U. S. Geol. Survey, Bull. 128. The Bear River formation and its characteristic fauna, C. A. White. 108 pp., 11 pls., 1895.

Illinois State Mus. of Nat. Hist., Bull. 7. New and interesting species of Palæozoic fossils. S. A. Miller and W. F. E. Gurley. 89 pp., 5 pls., Dec. 5, 1895.

N. Y. State Museum, Bull., vol. 3, no. 14. The geology of Moriah and Westport townships, Essex county, N. Y., J. F. Kemp. Pp. 323-355, 2 maps, Sept., 1895.

Geol. Survey of Canada. List of publications. 52 pp., 1895.

U. S. Nat. Museum, Bull. 39, pt. H. Directions for collecting minerals, Wirt Tassin. Pp. 1-6, 1895.

Same, pt. I. Directions for collecting rocks and for the preparation of thin sections, G. P. Merrill. Pp. 1-15, 1895.

Same, pt. K. Directions for collecting and preparing fossils, Charles Schuchert. Pp. 1-31, 1895.

Proc. U. S. Nat. Museum, vol. 17, 1895. Note on a blue mineral, supposed to be ultramarine, from Silver City, New Mexico, R. L. Packard:

An analysis of jadeite from Mogoung, Burma, O. C. Farrington: On the formation of stalactites and gypsum incrustations in caves, G. P. Merrill; The formation of sandstone concretions, G. P. Merrill; Notes on the invertebrate fauna of the Dakota formation, with descriptions of new molluscan forms, C. A. White; A review of the fossil flora of Alaska, with descriptions of new species, F. H. Knowlton; Discovery of the genus Oldhamia in America, C. D. Walcott; Distribution of the land and fresh water mollusks of the West Indian region, and their evidence with regard to past changes of land and sea, C. T. Simpson; Notes on some eruptive rocks from Gallatin, Jefferson and Madison counties, Montana, G. P. Merrill.

U. S. Nat. Museum, Rept. for 1893. The onyx marbles: Their origin, composition and uses, both ancient and modern, G. P. Merrill.

II. Proceedings of Scientific Societies.

Proc. Cal. Acad. Sci., sec. ser., vol. 5, pt. 1, 1895. A supplement to the bibliography of the Palæozoic Crustacea, A. W. Vogdes; The Neocene stratigraphy of the Santa Cruz mountains of California, G. H. Ashley; Geological map of the cape region of Baja California, G. Eisen and F. H. Vaslit.

Bull. Geol. Soc. Amer., vol. 7, pp. 67-94, Dec. 12, 1895. Geographical evolution of Cuba, J. W. Spencer.

Same, pp. 95-134, Dec. 20, 1895. Syenite-gneiss (Leopard rock) from the Apatite region of Ottawa county, Canada, C. H. Gordon.

III. Papers in Scientific Journals.

School of Mines Quarterly, Nov. The Missouri river, G. R. Morrison; Lecture notes on rocks, J. F. Kemp.

Journ. of Geology, Nov.-Dec. The Greenland expedition of 1895, R. D. Salisbury; A circum-insular Palæozoic fauna, Stuart Weller: Experiments in ice motion, E. C. Case; Absarokite-shoshonite-banakite series, J. P. Iddings; Distribution of gold deposits in Alaska, G. F. Becker.

Am. Chemical Journ., Dec. On the Composition of the Ohio and Canadian sulphur petroleums, C. F. Mabery.

Science, Dec. 27. Current notes on physiography (XXI), W. M. Davis.

Science, Jan. 3. The origin of hypotheses, illustrated by the discussion of a topographic problem, G. K. Gilbert.

Am. Jour. Sci., Jan. The quarries in the lava beds at Meriden, Conn., W. M. Davis; The form of isolated submarine peaks, G. W. Littlehales; Section of the Cretaceous at El Paso, Texas, T. W. Stanton and T. W. Vaughan: On the epidote from Huntington, Mass., and the optical properties of epidote, E. H. Forbes.

Am. Naturalist, Jan. Lost characteristics, Alpheus Hyatt; On the species of Hoplophoneus, G. I. Adams.

IV. Excerpts and Individual Publications.

The Yardley fault, B. S. Lyman. Proc. Am. Philos. Soc., vol. 34, pp. 381-384, pl. 10, Dec. 13, 1895.

The Chalfont fault rock, so called, B. S. Lyman. Ibid., pp. 384-388, pls. 11-12, Dec. 13, 1895.

The relative effects of frost and the sulphate of soda efflorescence tests on building stones, L. McI. Luquer. Trans. Am. Soc. Civil Eng., vol. 33, pp. 235-256, March, 1895.

Sixteenth Annual Report of the Director of the U. S. Geological Survey, C. D. Walcott. U. S. Geol. Sur., 16th Ann. Rept., pt. 1, pp. 1-130, pl. 1, 1895.

Notes concerning a peculiarly marked sedimentary rock from the vicinity of Glen Canyon, Arizona, J. E. Talmage. Utah Univ. Quarterly, Dec., 1895; 5 pp., 2 pls.

Charles Lyell and modern geology, T. G. Bonney. The Century Science Series; 16 mo, 224 pp.; New York, Macmillan & Co., 1895.

PERSONAL AND SCIENTIFIC NEWS.

A sketch of Ebenezer Emmons, with portrait, is given in the January number of *Appletons' Popular Science Monthly.*

Dr. Wm. C. Williamson's researches on Carboniferous flora are discussed by Mr. D. H. Scott in the December number of *Science Progress.*

A geological survey of Egypt is to be undertaken. It is expected to occupy three years and will cost £25,000. Capt. H. G. Lyons, R. E., has been appointed to have charge of the survey.

Dr. Oliver C. Farrington, curator of geology in the Field Columbian Museum, Chicago, left January 8th for Mexico, where he will spend the remainder of the winter collecting for the Museum.

Mr. Thomas A. Jaggar, Jr., A. M., on returning from Germany, has been appointed instructor in geology in Harvard University, giving his attention to experimental geology and to field-work.

Mr. H. Van F. Furman, of Denver, Colo., has been appointed professor of mining and metallurgy at the Colorado State School of Mines, in place of Mr. E. B. Kirby, resigned. (*Eng. & Mining Jour.*)

Mr. T. C. Hopkins, who has spent the last two years at the University of Chicago, has been appointed assistant professor of geology in the Pennsylvania State College, in which institution he was formerly instructor in geology.

The Geological Society of Washington met on Jan. 8th. The following papers were read:

The isthmus of Panama. R. T. Hill.
Recent and ancient markings on the seashore. C. D. Walcott.
Sand dunes on the Rhode Island coast. C. D. Walcott.
The occurrence of uintaite. G. H. Eldridge.

Dr. Charles Palache has been appointed assistant in mineralogy at Harvard University. Dr. Palache received the degree of B. S. from the University of California in 1891, was fellow in mineralogy there in 1892-93 and honorary fellow in 1893-94, received the degree of Ph. D. in 1894, and has spent the last year in advanced work at Göttingen. (*Science.*)

Mr. Henry A. Miers, of the department of minerals in the British Museum, has been appointed Waynflete professor of mineralogy in the University of Oxford, in place of Prof. Story-Maskelyne, resigned. In the December number of *Science Progress* Prof. Miers presents a popularly written article on "Mineral transformations" in which he calls special attention to pseudomorphs and to the ideas concerning the composition of some of the pseudomorphic minerals.

Terrestrial Magnetism is the name of a new international quarterly journal published under the auspices of the Ryerson physical laboratory of the University of Chicago. L. A. Bauer is editor, and he has the coöperation of thirty-four associates in this country and abroad. The journal is devoted exclusively to terrestrial magnetism and its allied subjects, such as earth currents, auroras, atmospheric electricity, etc. The first number was issued in January and contains fifty-four pages.

The Chicago Academy of Sciences has recently issued No. II, Vol. II, of its bulletins, with the publication of which the Academy enters upon a new era of activity. Its publications will be issued at regular intervals and will contain original matter of interest to all branches of scientists. The Academy property is now housed in a fireproof building of the best architectural construction, and no further fears of fire are entertained. C. M. Higginson is president, and Frank C. Baker secretary and curator.

The Binghamton (N. Y.) Academy of Science, which has been recently incorporated, held its first annual meeting on the afternoon of Jan. 8th and elected the following officers: president, Prof. E. R. Whitney; vice president, Prof. Herbert S. Jones; recording secretary, Willard N. Chute; corresponding secretary, Burt E. Nelson; treasurer, Joseph K. Noyes. In the evening the members of the Academy were tendered a reception by the Young Women's Christian Association at their rooms in the Strong building.

Stone-capped Pillars of Earth. Prof. H. B. Patton, of the Colorado State School of Mines, on Nov. 4, 1895, presented a number of photographs before the Colorado Scientific Society of "Peculiar geological formations at the head waters of the Rio Grande, Colo." Reproductions of some of these photographs accompany a brochure just issued by that society. The peculiar interest in these lies in the fact that they give us excellent examples of the effects of rain erosion on a volcanic ash; boulders which were embedded in this ash are now seen perched on the top of pillars or pyramids of the ash. The effect is strikingly similar to the earth pyramids or stone-capped pillars of the Tyrol described and figured by Lyell in 'Principles of Geology."

Mr. Robert T. Hill, of the United States Geological Survey, sailed on the 18th of January upon the third of a series of geological reconnaissances of the tropical American region, which he is undertaking under the auspices of Prof. Alexander Agassiz. He will visit many points of geologic interest concerning which knowledge is much needed. The plan of these researches is to acquire accurate detailed knowledge of typical regions in order that the whole of the complicated history may be ultimately interpreted. Mr. Hill's report upon the geology of the Isthmus of Panama and adjacent regions of Costa Rica, embodying the results of last winter's investigations, is nearly completed, and will deal minutely and thoroughly with the complicated and interesting geology of that region.

Cape Region of Baja California. Recently Mr. Gustav Eisen has presented a paper on "Explorations in the Cape Region of Baja California" (Proc. Cal. Acad. Sci., sec. ser., vol. 5, pt. 1, pp. 733-755, pls. 72-75, 1895), which contains one page on the geological features of the southern end of Lower California and a geological map of that district compiled by Mr. Eisen and F. H. Vaslit. The map shows the main portion of the region to be covered with rocks of volcanic origin, while in the highest parts are granitic rocks, and a small area of limestone occurs on the coast at the southeastern extremity of the cape. Mr. Eisen speaks of abundant signs of glacial action in the interior of the cape and of "enormous moraines, which all run more or less parallel from west to east." Several raised sea beaches, containing the remains of living species of shells were seen.

Dr. Ernst von Rebeur-Paschwitz.

Born Aug. 9, 1861. Died Oct. 1, 1895.

Dr. Ernst von Rebeur-Paschwitz was born on August 9th, 1861, at Frankfurt a. Oder. In consequence of his father's movements as a government officer, Von Rebeur's school was often changed, but wherever he went his knowledge of mathematics made him in these studies *facile princeps.* He obtained his doctorate at Berlin, where he became an assistant at the observatory. At Karlsruhe, where he was "Erster Assistant," he commenced, in 1884, to interest himself in Zöllner's pendulum. It was about this time that his health first caused anxiety to his friends. Although he visited Switzerland, Italy, Teneriffe and other places, returning to his home in apparently good health, it was soon recognized that his recoveries were only temporary. At Halle, where he was Privat Docent, the condition of his throat and chest precluded him from giving lectures. From 1891 until his death, on October 1st, 1895, he was more or less confined to a bed or sofa, often suffering excruciating pain, and never left his room except during the summer.

It was during this period of physical incapacity that Von Rebeur produced his most remarkable work, and became the pioneer of a new seismology. Commencing with the endeavor to measure lunar gravitation, he discovered the diurnal wave, that earthquakes could be recorded at stations distant more than a quarter of the earth's circumference from their origin, came in contact with the ubiquitous tremors and observed many other phenomena connected with the movements of our so-called *terra firma*. These discoveries attracted the attention of other observers, and horizontal pendulums were established at several of the more important observatories in Germany and Russia.

Von Rebeur's last work was an endeavor to obtain co-operation for the observation of these instruments throughout the world, a scheme, which, although he has not lived to realize it, will, in all probability, be accomplished in the near future. His ability and energy are testified by the works he leaves behind, and his modesty and kindly nature are spoken of by all who knew him. (*Geol. Magazine.*)

Ohio Academy of Science.

The fifth annual meeting of the Ohio Academy of Science was held at Cincinnati, by invitation of the Cincinnati Society of Natural History, on December 26th and 27th. The reading of papers on geology, especially those on the geology of Ohio, formed a prominent part of the meeting. The following geological papers were presented:

Whence came the Devonian fishes of Ohio? E. W. Claypole.

Observations on some Niagara limestone pits filled with clay. J. H. Smith.

The formation of natural bridges. Gerard Fowke.

The crystallized minerals of northern Ohio, particularly of the Lake Erie islands. Edo Claassen.

Formation of the beach flats of Pike county. W. G. Tight.

The evolution of several well known Paleozoic genera as shown by the introduction of new species. J. A. Bownocker.

The movement of glaciers. J. J. Janney.

The paleontology and stratigraphy of the Upper Helderberg rocks of central Ohio. J. A. Bownocker.

The origin of the Ohio river. W. G. Tight.

A new Titanichthys. E. W. Claypole.

Iowa Academy of Sciences.

At the recent meeting of the Iowa Academy of Sciences the following papers dealing with geological subjects were presented:

Recent developments in the Dubuque lead and zinc region. A. G. Leonard. Attention was called to the introduction of improved mining and pumping machinery which has allowed the recovery of ore from levels below any previously worked in the county.

Some facts brought to light by deep wells in Des Moines county, Iowa. F. M. Fultz. Deep wells penetrating 233, 184 and 188 feet in the drift are noted and interpreted as indicating preglacial river channels. This would indicate a much later date for the origin of the drainage than has been previously maintained by Mr. Fultz.

Recent discoveries of glacial scorings in southeastern Iowa. F. M. FULTZ. Striæ bearing S. 79° W., discovered jointly by Messrs. Fultz and Leverett, are noted and interpreted as indicating an extension into Iowa of the Illinois ice-sheet.

The Buchanan Gravels: An interglacial deposit in Buchanan county, Iowa. SAMUEL CALVIN. (Published in full in this issue of the AMERICAN GEOLOGIST.)

The Le Claire limestone. SAMUEL CALVIN. The Niagara formation includes three stages: (1) Delaware, (2) Le Claire, (3) Anamosa. The Le Claire is not sharply separated from the Delaware but is usually a more massive, more completely crystallized dolomite. In the upper layers small brachiopods, including *Homeospira*, *Trematospira*, *Nucleospira*, *Rhynchonella*, *Rhynchotreta*, *Atrypa* and *Spirifera*, are abundant. The Le Claire shows remarkable local variations in thickness and unique cross-bedding. The assumption that the local variations in dip are due to deformation is shown to be untenable. The angle at which the beds stand never exceeds that of stable slope for the fine wet calcareous material of which they were originally composed. The faunal and lithological variations follow the individual layers in their oblique courses.

Variation in the position of the nodes of the axial segments of the pygidium of a species of Encrinurus. W. H. NORTON. Recently collected and exceptionally good material shows that the pygidium varies too greatly to be of value in the determination of species.

A theory of the Loess. B. SHIMEK. From the results of studies upon the loess of Iowa and Nebraska, and particularly from a careful collection and study of the loess fossils, the author favors the æolian origin of the loess and advances strong arguments in its favor.

Two remarkable cephalopods from the upper Paleozoic. C. R. KEYES. Read by title.

Notes on the nature of cone-in-cone. C. R. KEYES. Read by title.

GEOLOGICAL SOCIETY OF WASHINGTON.

At the 41st meeting of this society, held in Washington, D. C., January 22d, two communications were presented, one by Mr. Arthur Keith, on the Crystalline Groups of the Southern Appalachians, and the other by Prof. Chas. R. Van Hise, of the University of Wisconsin and the U. S. Geological Survey, on Primary and Secondary Structure and the Forces that Produced them.

Mr. KEITH described seven classes of formations, in which no evidence of sedimentary origin appeared. These comprised gneiss and schist of three types, granite of five types, diorite of two types, gabbro of two types, peridotite and pyroxenite of five types, basalt and diabase of five types, andesite of two types, quartz porphyry and rhyolite of four types. These formations, occupy long narrow belts, comparable in extent with the sedimentary rocks, and belts of plutonic rocks alternate with volcanic rocks. Attention was called to the prevalence and attitudes of the schistose planes, due to deformation, and to the similar deformation of sediments and crystallines in the same area.

PROF. VAN HISE discussed the relations of secondary structures to the forces that produced them, and it was concluded that there have been two entirely different structures described under the term "cleavage." Following the English geologists, it was held that one of these structures develops normal to the pressure in a deep-seated zone of rock-flow, and that this ought properly to be called "cleavage." Following Becker, it was held that there have often developed two intersecting structure or shearing planes in the zone of fracture. For this structure the term "fissility" was proposed.

Dr. Becker in discussing Professor Van Hise's paper expressed himself as certain that true cleavages as well as ruptures are produced at large angles (not necessarily 45°) to the line of force. He regards the existence of such cleavages as well established, both by experiment and by theory. In his opinion no adequate theoretical or experimental basis exists for asserting that cleavage is normal to force, and field observations on slates have the exact direction of force to inference.

W. F. MORSELL.

WISCONSIN ACADEMY OF SCIENCES.

The Wisconsin Academy of Sciences, Arts and Letters held its annual meeting at Madison December 26th to 28th. The plan for the establishment of a geological and natural history survey of Wisconsin was not discussed. Two papers dealing with geological subjects were presented, abstracts of which are here given.

Origin of conglomerates. G. L. COLLIE, of Beloit College. In recent years authors have attributed many beds of conglomerates to glacial action, either directly or indirectly. This idea was first advanced by Rev. J. G. Cumming in 1848. The present paper aimed to show that there is no direct proof of ice action in conglomerate beds. Conglomerates originate in one of several ways: 1. By the breaching action of waves upon exposed rocky coasts. 2. By the disintegration of land surfaces and the removal of the harder portions of the débris to the sea, illustrated by Cambrian conglomerates in the Green mountains. 3. By the accumulation of pebbles in talus slopes, illustrated by the Ococe conglomerate, the Bishop Mountain conglomerate and the Siwalik conglomerates of India.

The conglomerates above enumerated are true basal conglomerates, being made up of débris derived from neighboring terranes. There is a class of conglomerates, not basal, that lie upon rocks from which they could not be derived. The author discussed this group, taking as a typical example the Pottsville conglomerate and showing that it was derived from a number of different points of origin, that it could not be a continental glacier that was concerned in its production, the mode of occurrence being too irregular and erratic for such an origin. Much of the material was derived from the south, not from the north as might be expected if glacial action were concerned. The conglomerate becomes very thick about certain centers and rapidly thins on passing away from these centers, thus showing that their derivation was local. The paper closed by stating that the ordinary agencies at work to-day are sufficient to account for conglomerates and there is no need to call in the aid of extraneous agencies.

Some stages in the development of rivers as illustrated by the Deer river, Michigan. J. MORGAN CLEMENTS, of the University of Wisconsin. The Deer river flows in a south-southeasterly direction through a pre-glacial valley which was not entirely obliterated by the deposition of the drift. The drift barriers formed across the valley as the ice retreated to the northeast ponded the water, creating lakes. The overflow trenched the barriers and connected the lakes by short streams. The effect of the draining and filling has been to obliterate the lakes and to accentuate the character of the stream. Near its mouth the river has built up alluvial flats through which it meanders, resembling in this part of its course the older streams of the Coastal plain of the United States. This resemblance is still more enhanced by the presence of a crescent-shaped cut-off, characteristic for the old age of rivers. Farther up the stream the lakes, whose life history is inseparably connected with that of the river, become more numerous and show various stages of development. The Michigan lumbermen have built numerous dams along the river, usually at the outlets of the lakes, and by replacing the barriers trenched by the river have rejuvenated some of the lakes. Others which had been drained have been regenerated, and thus the conditions existing during or shortly after the close of the Glacial epoch have been to some extent restored.

The source of the river is in the copious springs which are fed by the water of Bone lake, whose water level is about 30 feet above the springs and only 125 yards distant. A valley leads from these springs up to the lake, and at the shore is about 3 feet above the water. The outlet of the lake is the west branch of the Fence river, three-fourths of a mile distant from, and to the east of, the head of the Deer river valley. A dam at the lake outlet raised the water sufficiently to cause it to flow through the Deer river valley, adding temporarily to the Deer river system a stream 7 miles long, including in its course three large lakes. This necessitated, of course, a second dam at the head of the Deer river. No data are at hand which show whether or not the system thus artificially added to the Deer river originally belonged to it.

NEW YORK ACADEMY OF SCIENCE.

At the meeting of the section of geology and mineralogy held January 20th, Professor J. J. Stevenson in the chair, the following papers were presented.

The first by E. O. Hovey described the new and remarkably fine specimens of rare minerals recently discovered by Mr. Niven in the upper part of New York City. A double terminated tourmaline 9½ inches long by 4½ inches in diameter was shown, and also unusually large samples of xenotime and monazite. The largest xenotime was ⅜ inches in diameter, the monazite was about ⅝ inches on the long edge. Fuller crystallographical details appear in the Bulletin of the American Museum of Natural History of recent date.

The second paper was by J. F. Kemp and T. G. White and brought out the result of further exploration in the Adirondacks, the Lake Champlain valley and the Green mountains as regards the distribution of the trap dikes, well known from that region. One was cited on mount McIntyre about 4,000 feet above tide, and others from various interior points in the Adirondacks. Microscopic study shows that they are in instances both camptonites and fourchites. This modifies the previous experience of Kemp and Marsters, who had found only diabase dikes in the Archean rocks. A great number of dikes were mentioned from the shores of Willsboro bay, on the New York side; one dike of camptonite from the granite quarries near Barre, Vt., and one from the Eustis pyrites mine, near Sherbrooke, Que. These outlying dikes materially extend the area in which they had been previously known. Very curious exposures were also described as having been recently uncovered in the Willards Ledge quarries at Burlington, Vt. The paper concluded with some reflections on the petrology of the dikes. It will appear in full in the Transactions of the Academy.

This paper was followed by one by W. D. Matthew describing the metamorphism of Triassic coals at Egypt, N. C., by the intrusion of diabase dikes. Beginning with samples of coal at a distance of 70 feet from the dike it was shown that there is a progressive loss of volatile hydro-carbons as the igneous rock is approached, and that the bituminous coal passes into anthracite and this into prismatic coke next the dike. Geological sections and tables of analyses were shown. Attention was called to the fact that similar phenomena have been previously described from Virginia, but not from Egypt, N. C. The paper will appear in full in the transactions of the Academy.

The last paper was by J. J. Stevenson on "The Cerrillos Coal Fields near Sante Fé, N. M." Professor Stevenson brought out by means of geological sections that there were four coal seams contained between two laccolites of trachyte which had spread sidewise between the beds for nearly a mile from the parent dike or neck. In the topmost seam next the neck the coal was a graphitic anthracite passing, as the neck was left behind, into true anthracite which graduated into semi-bituminous and this into bituminous coking coal. The nearness of the laccolites appeared to exercise but little influence on the seams that were immediately over or under them, but the metamorphic change was due to the dike. The middle seam which is at a maximum distance from the two laccolites is bituminous coal throughout, so far as known, but it has not been worked near the dike. The speaker also referred to the change in our former ideas regarding the geology of the region, in that the intruded rocks have proved to be in two separate laccolites, where they were formerly thought to be innumerable dikes. The paper was discussed by J. F. Kemp, who referred to the fact that the metamorphic changes were doubtless due to vapors or heated waters set in circulation by the dike, to which the speaker assented.

J. F. Kemp, Sec'y.

Glacial Lakes of the Boston Basin.

At the meeting of the Boston Society of Natural History on January 1, 1896, Prof. W. O. Crosby and Mr. A. W. Grabau read papers showing that the chief deposits of modified drift in and about the Boston basin are referable to a series of glacial lakes along the southern and western borders of the basin. These lakes, which existed between the receding margin of the ice-sheet and the watersheds of the streams tributary to Boston harbor, were subject to great variations in outline, area, and level. During the period of their maximum and most interesting development, the general trend of the ice margin was from east to west along the southern border of the basin, and thence north and northwest across the western end of the basin from the Blue hills to the highlands of Weston and Waltham.

Along the south side of the Boston basin, in Hingham, Weymouth, Braintree, Randolph, and Quincy, was formed *lake Bouvé* (named in honor of Mr. Thomas T. Bouvé, a former president of the Boston Society of Natural History), some twelve miles long. Its different levels, as determined by successively lower outlets, first, southward into North river, and later eastward into Cohasset harbor, were approximately 140 feet above the sea (shown by the modified drift tract in Hingham called Liberty plain), 70 feet (Glad Tidings plain), and 50 feet (the Lower plain). [These sand and gravel plains, all situated in the township of Hingham, with the general geology of this township, including its formations of granite and diorite, melaphyr, conglomerate, sandstone, and slate, also noteworthy eskers and many large drumlins, are well described by Mr. Bouvé in the History of Hingham, vol. I, 1893, pp. 1-74, with five geological maps and seven figures in the text.]

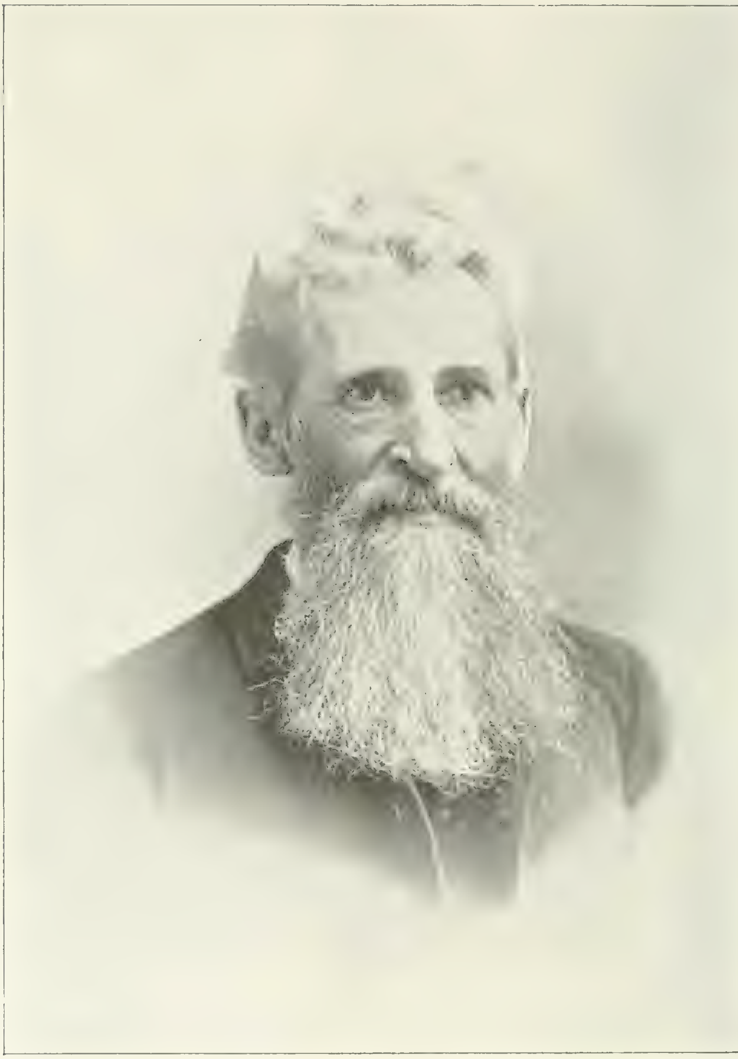
Other glacial lakes were formed in the upper basins of the Neponset and Charles rivers. At their highest levels (240 to 300 feet above the present sea level) these lakes were independent, and were tributary, respectively, to the Taunton and Blackstone rivers. But at the level of 200 feet they were confluent, and had a common outlet, into the valley of the Taunton river. Still later, an outlet was opened eastward along the south side of the Blue hills into lake Bouvé at a hight of about 160 feet. The plains formed during this final stage of the *Charles-Neponset lake* extend eastward across Wellesley and Needham into Newton and West Roxbury, and northward across the broad water-parting (now occupied by lake Cochituate) between the Charles and Sudbury rivers, and thence, apparently, down the valley of the Sudbury and Concord rivers into Billerica.

The western edge of the inclosing lobe of the ice-sheet appears to have receded eastward more rapidly than the southern edge receded northward, so that the ice continued to form a barrier across Boston harbor after it had disappeared from all the country between the Blue hills and

Arlington Heights. The drainage of the Neponset and Charles basins thus eventually became tributary to lake Bouvé along the north side of the Blue hills, at the hight, first, of the Glad Tidings plain, and, later, of the Lower plain. Level tracts of modified drift at these hights have an extensive development in the lower valleys of the Charles and Neponset rivers, and also in the upper valley of the Mystic river, outlining a body of standing water which it is proposed to call *lake Shawmut*, from the Indian name for the original peninsula of Boston.

The authors would also trace a relationship of the modified drift plains in the Concord and Shawsheen river basins with lakes Shawmut and Bouvé, as formed in a more northern glacial lake tributary to these; but perhaps conditions of wholly fluvial drainage southeasterly toward Boston, while the ice-sheet still covered the lower part of the course of the Merrimac river east of Lowell and Lawrence, may have been adequate to give the large areas of modified drift stretching across Wilmington, Billerica, and Tewksbury, to Lowell.

Excepting the glacial lake Contoocook, described by Upham eighteen years ago in the third volume of the Geology of New Hampshire, these lakes Bouvé, Charles-Neponset, and Shawmut, are the first glacial lakes clearly defined and named in New England.



Charles Wachsmuth

THE

AMERICAN GEOLOGIST.

VOL. XVII. MARCH, 1896. No. 3.

BIOGRAPHICAL SKETCH OF CHARLES WACHSMUTH.

By CHARLES R. KEYES, Jefferson City, Mo.

(Portrait, Plate VI.)

By the death of Charles Wachsmuth American paleontology loses one of its brightest lights. Notwithstanding the fact that he was compelled to lead a retiring life and was seldom seen at public gatherings, no one person did more to raise to the high plane that it now occupies the department of knowledge which he represents. The world's final judgment as to his true worth to the science must be based upon the monuments he has left.

Although possessing from early childhood a delicate constitution which continually threatened to give way, Mr. Wachsmuth withstood the inroads of an organic disease long enough to nearly complete the allotted span of human life of three score years and ten. During the last three years his health gradually failed until for several months past herculean efforts were necessary to enable him to work even for a short time each day. His last illness covered only a few days; and even the iron will, which had so often before overcome a long standing chronic ailment, finally had to give up to the physically weak heart. To within a day of his demise, with a zeal that is begotten only of a love for the sublime, he continued to apply himself to the finishing stages of the crowning glory of his life—a Monograph on the Fossil Crinoids. The first half only was written and the final proofs were being read when the angel of death beckoned him. The triumphant joy of beholding the completed structure of a noble life's work was not his lot. Deprivation of what he held dearest took the place of conquering satisfaction in the very hour of victory. Inscrutable laws we seek to comprehend and striving, strive in vain.

Charles Wachsmuth was born September 13, 1829, in the city of Hannover, Germany, and died February 7, 1896, at Burlington, Iowa. He was the only son of Christian Wachsmuth, a lawyer of considerable reputation and a member, in 1848, of the German parliament at Frankfurt. Although in feeble health almost from the hour of his birth, it was the wish of his father that young Wachsmuth should study law, and he was accordingly sent at an early age to the gymnasium of his native place to receive a classical education; but to his father's great grief and his own he was obliged at the age of sixteen to give up all studies on account of failing health, and on the advice of the attending physician entered the mercantile career.

In 1852 the subject of our sketch came to America, having been sent to New York as an agent of a Hamburg shipping house, in which capacity he served for a period of over two years. This gave him an excellent opportunity to see the great West, which made on him a very favorable impression. As the climate of New York did not agree with him, he concluded, after barely recovering from a severe attack of pneumonia and while still very feeble, to try to find relief in the West in a change of climate. At the suggestion of friends it was decided to go to Iowa, then a young but promising state. The town of Burlington was finally selected in which to dwell, but without the slightest suspicion of the treasures which were there in store. In 1855 Mr. Wachsmuth was married to Miss Bernandina Lorenz, also a Hannoverian. In the same year he embarked in business on his own account. The dry western country did not afford the expected improvement in health and the consulting physician advised that as much time as possible should be spent in the open air, and that for exercise fossils should be collected. It did not take long to develop into an enthusiastic collector, so that the greater part of the days were spent in the quarries and ravines around the city, his wife often looking after the store. This mode of life was at once apparent in a wonderful improvement in health. In the course of a few years a fine collection of crinoids had been brought together. It reached such dimensions that it attracted the attention of eastern scientists. Prof. Louis Agassiz came to see it on his lecturing trips to the West; and Meek and Worthen asked the loan of specimens for description in the geological reports of Illinois, which were then being prepared.

In 1865 Mr. Wachsmuth closed out his business and, accompanied by his wife, made a trip to Europe. On his way he visited Cambridge, upon invitation from Prof. Agassiz, and saw the large collections in the Museum of Comparative Zoölogy. This awakened a keen interest. Until then he had seen very few crinoids aside from those found at Burlington. His delight knew no bounds when he could study in Cambridge the fossil crinoids from other localities, and a number of specimens of living types. In Europe all sorts of invertebrate fossils were collected and visits made to the principal museums. When England was reached it was a great surprise to find that the reputation of the Burlington collection already had preceded him.

On returning to Burlington, after an absence of almost a year, Mr. Wachsmuth resolved to devote the rest of his life to scientific pursuits, and to direct his whole attention to the crinoids. Living far from any of the scientific centers, and not having access to the literature, he had to depend for study largely upon his own specimens. This, however, proved afterwards an advantage, necessitating independent thought and original research. The various state reports to which there was access gave a superficial knowledge of the principal genera, but they did not throw much light upon the morphology of the class, in which the greatest interest centered. Of great help was a visit of F. B. Meek, who came to Burlington in the interest of the Illinois Geological Survey to study the collection. During the preparation of the fifth volume of that organization several unique structural specimens were found, which seemed to throw light upon the mouth and ambulacra of the ancient forms. The specimens aroused Mr. Meek's interest in a high degree, as proving conclusively that at least in some of the older forms mouth and ambulacra were subtegminal.

It was in 1873 that Prof. Agassiz, on his return from the Pacific coast, paid a second visit to Burlington. He was greatly surprised at its enormous growth since he had last seen the collection and, struck by the beauty and perfection of the specimens, he intimated that he was anxious to procure the collection for Cambridge, and expressed a desire to have Mr. Wachsmuth go with it and take charge of all the crinoids in the museum there. The negotiations were soon completed, and a few months later, Mr. Wachsmuth was installed in the Museum of Comparative Zoölogy as an assistant. It was Prof. Agassiz who induced him to publish the results of his observations under his own name, on the ground that he was doing an injustice to himself by placing them in the hands of others. The position, which was held until the death of Prof. Agassiz, gave ample opportunity to become fully acquainted with the literature on the crinoids, and it was here that the foundation was laid of a classification which divides all Paleozoic crinoids into three primary groups, based chiefly upon the structure of the tegmen. These groups were sketched out in 1877 in a paper "On the Internal and External Structure of Paleozoic Crinoids," and they are now recognized as primary divisions with the rank of order.

On returning from a second trip to Europe and a visit to the Orient, in 1874, Mr. Wachsmuth found not a single specimen in his possession. It took only a few years, however, to make up another collection that was larger and much superior to the first. A year or two later he made the acquaintance of Mr. Frank Springer, then a young lawyer at Burlington, and an enthusiastic student of the natural sciences. A friendship soon sprung up between them. They studied together, and from 1878 the results of their researches were published under joint authorship. In the following year the collections increased rapidly by extensive purchases, and on a trip to Europe Mr. Springer brought home a fine selection of Dudley crinoids, embracing nearly all the species of that locality, and a large lot of the Carboniferous species of England and Ireland. Among his acquisitions were also the rarer forms from Belgium, a majority of the Eifel species, fine specimens from

Russia and Bohemia, and a large amount of material from Mesozoic and later formations. The collection was enlarged further by extensive exchanges with collectors in this country and Europe, and by having collectors in the field. Liberal purchases for the library were made, and when work was commenced on the monograph nearly the whole crinoidal literature, from the time of J. S. Miller to date, was at hand. By examining the titles of their publications it will be noticed that Wachsmuth and Springer took very little pride in describing new species, their attention being directed mainly to the morphology, with a view to classification, and to the revision of work of the earlier writers. As the work of the monograph was nearing completion Prof. Alexander Agassiz, director of the Museum of Comparative Zoölogy, offered to publish it in the best style possible as one of the memoirs of the Museum and in this form it appears as a model of typographic art.

Mr. Wachsmuth was a fellow of the American Association for the Advancement of Science, of the Geological Society of America and of the Iowa Academy of Science. Of the latter he was at one time vice-president. He was also a corresponding member of the Philadelphia Academy of Sciences and a member of the Imperial Society of Natural Sciences of Moscow, Russia. For many years an extensive and intimate correspondence has been carried on with leading scientists of this country and Europe. That which passed between the late Dr. P. Herbert Carpenter and Mr. Wachsmuth during the last ten years would alone fill a large volume.

For many years Mr. Wachsmuth has been in such delicate health that he has had to spend the winters in the South. The early spring months have been spent in the mountains of Alabama, Tennessee and Kentucky, where immense collections of both crinoids and blastoids have been brought together. On all of these trips he has been accompanied by his faithful wife, who is herself an excellent and indefatigable collector, an enthusiastic worker and an admirer of all that pertains to fossil crinoids. Indeed it may be questioned whether she has not found as many and as rare specimens as the savant himself. Were it not for her tutelary presence the monograph of American crinoids might never have seen the light of day.

The following are the principal scientific works that have been published by Mr. Wachsmuth, chiefly with the collaboration of Mr. Frank Springer:

1866. Evidence of Two Distinct Geological Formations in the Burlington Limestone. (Am. Jour. Sci., [2], vol. 42, pp. 1-7, 1866.)

1877. Notes on the External Structure of Paleozoic Crinoids. (Ibid., [3], vol. 14, pp. 115-127 and 181-191, 1877.)

1877. Revision of the Genus Belemnocrinus, and Descriptions of Two New Species. (Ibid., [3], vol. 14, pp. 253-259, 1877.)

1878. Transition Forms in Crinoids. (Proc. Acad. Nat. Sci. Phila., 1878. pp. 224-266, 1878.)

1879. Revision of the Palæocrinoidea: Part I, Ichthyocrinoidæ and Cyathocrinoidæ. (Ibid., 1879, pp. 226-379, 1879.)

1881. Revision of the Palæocrinoidea; Part II, Sphæroidocrinoidæ. (Ibid., 1881, pp. 177-414, 1881.)

1883. Remarks on Glyptocrinus and Reteocrinus, two Genera of Silurian Crinoids. (Am. Jour. Sci., [3], vol. 25, pp. 225-268, 1883.)

1883. Hybocrinus, Hoplacrinus and Bærocrinus. (Ibid., [3], vol. 26, pp. 365-377, 1883.)

1885. On the Challenger Report on the Stalked Crinoids. (Science. vol. 6, pp. 138-139, 1885.)

1885. Description of Fossil Invertebrates. (Illinois Geol. Sur., vol. 7, pp. 339-345, 1885.)

1885. On a New Genus and Species of Blastoids. (Ibid., vol. 7, pp. 346-357, 1885.)

1885. Description of a new Crinoid from the Hamilton Group of Michigan. (Proc. Davenport Acad. Sci., vol. 4, pp. 94-96, 1885.)

1885. Revision of the Palæocrinoidea; Part III, Section I. (Proc. Acad. Nat. Sci. Phila., 1885, pp. 225-364, 1885.)

1886. Revision of the Palæocrinoidea; Part III, Section II. (Ibid., 1886, pp. 64-226, 1886.)

1887. Summit plates in Blastoids, Crinoids and Cystids, and their Morphological Relations. (Ibid., 1887, pp., 82-114, 1887.)

1888. Discovery of the Ventral Structure of Taxocrinus and Haplocrinus, and Consequent Modifications in the Classification of the Crinoids. (Ibid., 1888, pp. 337-390, 1888.)

1888. Crotalocrinus: its Structure and Zoölogical Position. (Ibid., 1888, pp., 364-390, 1888.)

1890. Perisomic Plates of the Crinoids. (Ibid., 1890, pp. 345-392, 1890.)

1890. New Species of Crinoids and Blastoids from the Kinderhook Group of Le Grand, Iowa. (Illinois Geol. Sur., vol. 8, pp. 157-251, 1890.)

1892. Description of Two New Genera and Eight Species of Camerate Crinoids from the Niagara Group. (American Geologist, vol. 10, pp. 135-144, 1892.)

1895. Monograph of the Crinoidea Camerata of North America. (Memoirs of Museum of Comparative Zoölogy, 2 vols., 800 pp., and atlas of 83 plates. comprising 1500 illustrations, 1895.)

THE STRUCTURE OF CERTAIN PALEOZOIC BARNACLES.

By J. M. CLARKE, Albany, N. Y.

(Plate VII.)

The courtesy of Mr. Clifton J. Sarle, of Rochester, N. Y., in placing in my hands for examination a nearly, if not quite entire example of the peculiar cirripede genus *Lepidocoleus*, has afforded me an opportunity of elaborating its structure and indicating its relations to some other early forms of lepadoid barnacles.

The detached plates of such animals seem to be pretty widely diffused through Paleozoic faunas. Under the names *Turrilepas* and *Plumulites* they have been described by various writers, from the Trenton group of Canada, the Hudson River group of Ohio, the Wenlock and Dudley limestones, the étages D and E of Bohemia, the Corniferous limestone of the lower Devonian, the Hamilton shales of the middle Devonian in New York, and the Cleveland shale of the Upper Devonian of Ohio. Yet only in isolated instances have these plates been found together so that any definite conception can be obtained of the form of the structure to which they belong. Dr. Henry Woodward has given figures of the most complete specimens yet known. In describing the genus *Turrilepas** he based his account upon well preserved examples of the species previously known as *Chiton wrightianus* de Koninck, a Dudley fossil. One of the specimens figured in this paper is apparently complete and undisturbed (pl. 14, fig. 1*h*), but it is stated to have been received after the reading of the paper and is in consequence not specifically mentioned in the description. This specimen indicates an elongate strobile-shaped body constituted of overlapping subtriangular plates arranged in not less than four vertical rows, in two of which the plates are of much larger size than in the others. Dr. Woodward recognized the probability that "the two broad rows of intersecting plates correspond with the lateral rows of plates, and the two minute rows [shown in his figures 1*c*, *e* and *h*] with the carinal and rostral series along which the specimen seems more readily to have divided as in the case of *Loricula*." No better specimens of this genus have been des-

*Quart. Journ. Geol. Soc., 1865, p. 486, pl. 14.

cribed than these from the Wenlock limestone, but the terminal structure of the fossil, which, it would seem, must be normally retained in specimen 1*h*, was not especially delineated. The author expresses the view that the opercular or capitular plates are unknown, and is, hence, evidently to be understood in this expression as regarding these bodies the scale-coated peduncle of the barnacle; a view not altogether congruous with the expression just quoted. The fossils which were shortly thereafter described by Barrande under the name *Plumulites** are of similar structure, but none of the figured examples are sufficiently complete to afford definite evidence of the number of vertical series of plates. Individual plates in these specimens are notably more lanceolate or leaf-shaped than those composing the Dudley specimens and quite similar in this respect to many of the isolated plates described from the Devonian of New York. Barrande expressed the view that the bodies were composed of not less than four vertical rows of plates, and it would seem that *Pl. bohemicus*, as represented in fig. 1 (pl. 20), must have had a greater number than this, all composed of these leaf-like plates of nearly equal size. On the other hand *Pl. folliculum*, represented in fig. 17 (pl. 20), appears to have but two rows, both of large carinate plates. This author repeatedly refers to the absence of the peduncle in his specimens and it is to be inferred that he regarded the bodies as capitula. Though neither Woodward nor he is specific in this expression, they evidently differed somewhat in their conception of these bodies, both agreeing, however, that they are barnacles allied to *Loricula*. The allied genus *Strobilepis*, described by the writer from the Hamilton group of New York, consists of four vertical rows of plates, two of which are of large size and symmetrical with reference to each other; the other two, placed between the principal series, are small and accessory, that on the ventral side being modified into spines, and the other being composed of little plates having the general aspect of the major plates but more obtuse and not medially carinate. *Strobilepis* is a barnacle whose plates are large and massively calcareous in comparison with *Turrilepas*, and which terminates in a subcircular patelliform caudal plate having its apex inclined

*Syst. Sil. Centr. Boheme, vol. 1, suppl., pls. 20, 35; 1872.

toward the ventral side of the body. This latter feature alone demonstrates, so far as comparisons can be drawn between this fossil and the living Thoracica, that *Strobilepis* at least includes the so-called capitular portion of the shelled barnacles.

The genus *Lepidocoleus* was introduced by Charles L. Faber* for a cirripede from the Hudson River rocks at Cincinnati. According to Mr. Faber's identification the species upon which the genus is based is that described from isolated plates by Hall and Whitfield as *Plumulites jamesi*.† The Cincinnati specimen is apparently entire and shows very distinctly the points of structure upon which the generic diagnosis is based. The fossil consists of but two vertical rows of plates and these are so arranged as to exclude the possibility of any additional accessory rows. These plates have reversed symmetry and corresponding ones are of the same size, but each is decidedly unsymmetrical in itself. The apices are situated at one edge (which Mr. Faber has accurately termed the dorsal edge) of the flat body and thus those of the two rows lie in close apposition. From this apex there is a very short slope on the narrow dorsal surface and a very long slope over the side to the ventral edge. The fine ornamental lines are concentric to the apex and thus increase the appearance of asymmetry in the plate. The plates in each of the two series overlap each other for one-half or two-thirds of their length so that but a narrow portion of each is exposed. The members of the two rows alternate with regularity at the dorsal edge so that the individual plates do not occupy symmetrical positions, each being a little further forward than that most closely adjoining it on the opposite row. On the dorsal edge the elevation of the apex is continued into a slight thickening or ridging of the ante-lateral slope of each plate. The plates of the two series come together in direct apposition without overlap on the ventral edge. The resultant form of the fossil is, hence, elongate blade-shaped, with broad sides, a narrow dorsal and sharp linear ventral edge. Faber's specimen also shows a strong flexion of the three or four basal plates toward the ventral side. The author gives no details

*Journ. Cinti. Soc. Nat. Hist., p. 14, pl. 1, figs. A-F; 1887.
†Palæont. Ohio, vol. 2, p. 106, pl. 4, figs. 1, 2.

of the structure at the distal, apical extremity and the figures indicate that the specimen is broken at this point.

The example received from Mr. Sarle is from the shales of the Niagara group at Rochester, N. Y. We shall call it *Lepidocoleus sarlei.* The single specimen has suffered no distortion and has very much the same blade-like form as *L. jamesi.* It has, perhaps, lost one or more of its basal plates over the flexed portion of the body, as our specimen bears thirteen plates on one side and twelve on the other. The thirteenth, however, is terminal and axial, and belongs as much to one series as the other. The Cincinnati specimen of *L. jamesi* is stated to bear fifteen plates on each side, and in the Lower Helderberg species, *L. polypetalus*, the example described below bears seventeen plates, though it is incomplete at both ends, and shows very slight evidence of basal flexion. Yet the structure of the best preserved specimen indicates that the basal flexion is a normal and not a casual feature of the genus. The entire length of the specimen of *L. sarlei* is 23 mm., about twice that of Faber's *L. jamesi*, and probably not much more than one-half the length of *L. polypetalus.* The structural characters are in general harmony with those upon which the genus is based. The degree of overlap of successive plates seems to be greater than in *Turrilepas* and probably amounts to fully two-thirds of the entire length of the plate. The exposed portions on the lateral surfaces are narrow, ribbon-like bands, while, if the curvature of the concentric lines be carried out, the form of the plate must be subsemicircular. No isolated plate of the species has been met with and that at the base of the specimen, shown somewhat obliquely in the figure, is the only one giving any suggestion of the full outline.

The distal or caudal extremity has the following structure: The terminal plate on the left side extends beyond that on the right side. Viewed from the dorsal side this plate is seen to be median and axial as well as terminal. Its back is narrow and grooved to the tip, the groove thus begun being continued forward, enlarging in width, becoming deeper and with more elevated edges which are eventually lost or obscured by the overhanging apices of the plate. Where this dorsal furrow is exposed near the caudal extremity oblique lines of union, or very closely matched lines of overlap, are distinctly exposed.

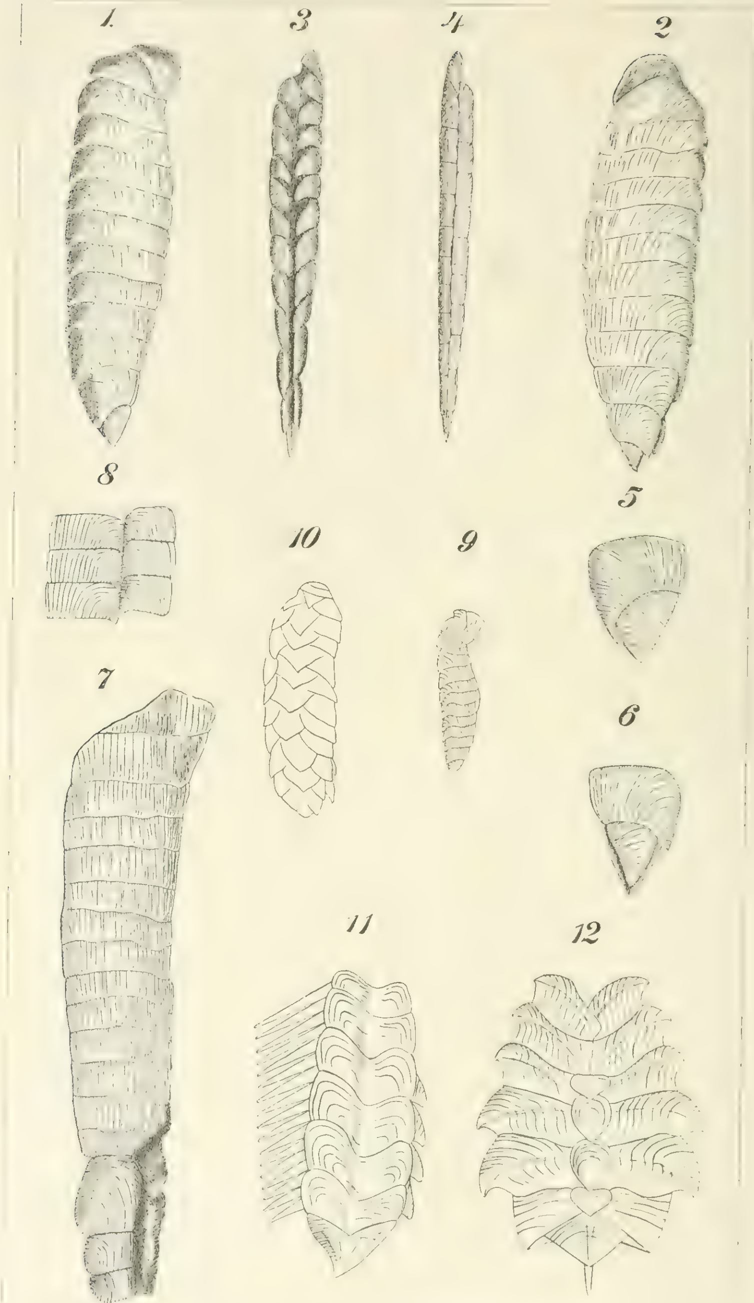
The relation of the terminal plate of the right side to the caudal plate is simple, the latter apparently lying partly within the concave interior of the former, sufficiently so to be overlapped by it at the dorsal edge, so that the plate does not appear in dorsal view. The demonstration of an axial caudal plate in *Lepidocoleus* and *Strobilepis* determines the fact, paradoxically enough expressed, that these fossils certainly embrace the so-called capitulum of the Thoracica.

It is evident that in *Lepidocoleus* we have to do with a highly simple unmodified form of cirripede, and it is unnecessary to debate whether the fossil represents the capitulum or the peduncle of living barnacles; as just observed, it undoubtedly includes the former and we have the best reason for believing that it is the entire exoskeleton of the animal. The sharp, linear ventral edge where the thin margins of the plates come into apposition without any sort of union was unquestionably a line of voluntary dehiscence for the protrusion of the appendages. There is no evidence that the animal was of parasitic habit and we believe in the propriety of the assumption that inasmuch as the same simple arrangement of the plates is continued throughout the extent of the body, save at the caudal extremity, these quite fully represent the entire length of the animal. The body plates, taken at a side view when the fossil is properly oriented, show a typical crustacean segmentation. However different this appearance may be from the actual condition arising from the fact that the body plates are unsymmetrically placed on the two sides, yet a priori evidence is very strong that these are but a slight departure from the primitive simple segmented somatic condition to the highly modified test division of the typical cirripede.

It is true that there is no basis for these assumptions in the ontogeny of living Thoracica. In both *Lepas* and *Balanus* the nauplius after various moults passes directly into a short-lived Cypris-stage, thereupon becoming attached and at once assuming ephebic characters, but in forms so radically modified as are these, some of the ontogenic steps have been hastened and the record abbreviated. Hence there is here no phase parallel to the primitive condition of structure represented by *Lepidocoleus*.

A third species of *Lepidocoleus*, *L. polypetalus*, occurs in the shaly limestone of the Lower Helderberg group. The singled observed specimen, which is from Albany county, N. Y., is incomplete, being broken at both extremities and somewhat obliquely crushed, so that only a portion of one of the broad sides is exposed for the principal part of the specimen, the dorsal margin with the approximate apices of the valvular plates being on the under side of the specimen, only a part of which has been set free from the matrix. Toward the upper or distal end of the specimen are three plates which retain their convexity. This species is very much larger than either of the others and the fragment bears seventeen plates. Evidently several more are needed to complete the test. This is a number considerably in excess of what seems to have been the full number in the other species, and we are led to infer, from the apparent approximate completeness of the other specimens, that the number of plates varied with the species. The specimen of *L. polypetalus* though showing a slight basal curvature has this feature not very well developed, probably from the absence of the basal plates. The greater size of the species is not, however, wholly due to the greater number of plates; the plates themselves are individually larger than those of the other species. The original fragment has a length of 35 mm.

It is not likely that this primitive, slightly modified cirripede structure represented by *Lepidocoleus* should be closely classed with forms like *Strobilepis* and *Turrilepas* which are provided with four or more vertical rows of plates. The presence of accessory rows between the major series, one on the dorsum and another on the venter, must have involved an essential modification of function,if in no other way, by closing the ventral aperture for the protrusion of the appendages. It is far easier to conceive the relations of the animal to the shell in *Lepidocoleus* than in the case of these multiseried cirripedes. Authors and compilers have generally included *Turrilepas* with *Lepadidæ*, and yet the relations of the fossil and its ally *Strobilepis* to *Lepas*, *Loricula* or any typical member of the



PALEOZOIC BARNACLES.

family are very remote. It would be in much closer accord with our knowledge of these bodies, incomplete though it may be, to place them in a separate family, the *Turrilepadidæ*, and to dissociate them at the same time from the somewhat similarly constituted but more primitive bodies, *Lepidocoleus*, by placing the latter in a distinct family, *Lepidocoleidæ*.

Explanation of Plate VII.

Lepidocoleus sarlei, sp. nov.

Figs. 1 and 2. Opposite sides, showing the narrow, ribbon-like exposure of the plates upon the lateral surfaces. ×2.3.

Fig. 3. The dorsal edge, showing the axial position of the terminal plate and the mode of interlocking of the plates near the extremity. The apices of the plates of the two rows do not come into actual contact but are separated by a groove, along which it is to be presumed that the plates interlock as do those near the caudal end. ×2.3.

Fig. 4. The ventral edge, showing the alternating positions of the plates in the two rows. ×2.3.

Fig. 5. The ultimate and penultimate plates of the right side; the former is the caudal or apical plate. ×4.6.

Fig. 6. The last two plates of the left side. The ultimate plate here is overlapped by the edges of the caudal plate. ×4.6.

Niagara Shales, Rochester, N. Y.

Lepidocoleus polypetalus, sp. nov.

Fig. 7. The exposed surface of the original specimen. ×2.3.

Fig. 8. A portion of the flattened dorsal surface of the concealed side. ×2.3.

Lower Helderberg group, Albany county, N. Y.

Lepidocoleus jamesi (Hall and Whitfield) Faber.

Fig. 9. An outline copy of one of Mr. Faber's figures. ×2.3.

Hudson River group, Cincinnati, Ohio.

Turrilepas wrightiana (de Koninck) Woodward.

Fig. 10. An outline copy of Woodward's figure. Natural size.

Wenlock limestone, Dudley, England.

Strobilepis spinigera Clarke.

Fig. 11. An approximate restoration of the form of this fossil, viewed from the side, showing the ventral row of spines and the dorsal row of small plates.

Fig. 12. A dorsal view of the same. Slightly enlarged.

Hamilton shales, Canandaigua lake, N. Y.

THE MINERAL DEPOSITS OF EASTERN CALIFORNIA.

By Harold W. Fairbanks, Berkeley, Cal.

Introduction.

The portion of California lying east of the crest of the Sierra Nevadas has a mineral character which in many respects is quite unlike that of the rest of the state. Very little has been published about the ore deposits occurring here, although they are quite important economically and strikingly interesting from a mineralogical point of view. On that account it has seemed that the following observations and discussion may be of some value. They are based on the examination of all the important mining districts between northern San Bernardino and Alpine counties. The area is bordered on the west by the Sierra Nevada mountains and is traversed in a general north and south direction by high and rugged ranges between which lie the desert valleys.

Types of Ore Deposits.

The important ore deposits can be divided into two classes: (1) gold, (2) silver and lead. Of the silver ores two distinct classes may be considered: (a) argentiferous galena, generally in the form of chamber deposits; (b) silver bearing sulphides of antimony, arsenic and copper, occurring in well defined veins with a gangue of quartz.

As a rule each of these classes of ores is strongly marked in its manner of occurrence, although there are important exceptions. Almost all the gold deposits contain silver in appreciable quantity and at times the value of the two metals is nearly equal. The important silver deposits on the contrary contain very little gold.

Distribution and Geologic Relations of the Gold Ores.

Commencing in the southern portion of the area in question the important gold districts will be briefly described for the purpose of illustrating the exceedingly varied conditions under which that metal occurs.

Near Post Office springs in the Panamint range gold is found in quartz veins inclosed in limestone. This rock, exposed in immense cliffs on the south side of the cañon, has been folded in a syncline with slates below and on the sides. Much of the limestone is penetrated by minute branching veinlets of quartz which appear prominent on weathered surfaces. No gold is found in these but in five fairly regular veins from a few inches to two feet in thickness. The ore is high grade, the gold being present on the surface in the free state, but judging from the appearance of the quartz it was originally contained in iron pyrites.

A large number of gold bearing quartz veins are scattered through the southern portion of the Argus range. They are inclosed in a great body of granite which extends from San Bernardino county north through the Coso mountains to Owen's lake. The deposits are being worked in a number of places and appear to be quite rich. The character of the quartz makes it seem probable that some distance below the surface most of the gold will be found contained in iron pyrites. Chalcopyrite and galena are abundant in some of the veins and carry considerable silver.

With the exception of numerous areas of volcanic rocks the Coso mountains consist wholly of granite, the mineral deposits being confined to the latter rock. The quartz veins are characterized by the presence of free gold on the surface, while at depths varying from 250 to 400 feet the free gold has been found to be largely replaced by iron pyrites with a subordinate amount of chalcopyrite.

The Beveredge gold district is situated on the eastern slope of the Inyo range at an elevation of 5,000 to 8,000 feet. The veins are confined to a large body of granite which has broken through the metamorphic series. Many of the veins are nearly vertical while others are quite flat, dipping 20 degrees or less, and being locally known as blanket veins. The mine which has been worked the longest and most steadily is known as the Keynote. A depth of 700 feet has been reached on the incline and the ore, which was free milling on the surface, has been found with increased depth to contain a greater proportion of iron pyrites and chalcopyrite. In the American Flag mine at the southern end of the district gold is found associated with galena and even imbedded in it. The Chilula mine lies partly in limestone and partly in granite. The portion of the vein in granite carries gold, but upon passing into the limestone the gold is replaced by silver ores. This seems to be a good illustration of the physical influence of the wall upon the ore. One of the largest veins of the district dips at an angle of about 20 degrees into a precipitous granite ridge. Where it has been opened the average thickness is four to seven feet, swelling in places to 20 feet.

A number of small but rich gold bearing quartz veins are found on Fish Spring hill, a granite outlier of the Sierra Nevadas. There are two systems of veins here, the one vertical, the other nearly flat. As far as developed the quartz of the district shows free gold with copper and iron sulphides.

A group of veins carrying gold and silver occurs in limestone at the western base of the Inyo range, southeast of Independence. The gold is associated with quartz and iron and copper pyrites, while the silver is contained in galena which occurs in bunches in different portions of the vein.

A quartz vein is found in granite in the foothills of the Inyo range north of Independence. It has a vertical position and is traceable for nearly a mile. The character of the quartz makes it apparent that the gold was originally contained in iron pyrites.

Beginning at a point east of Bishop creek a gold belt extends northward along the western slope of the White Mountain range for about ten miles. This belt is interesting because of the great variety in the character of the ore and wall rocks of the many different veins. At the southern end are a number of small veins in granite, two sets of fissures being distinguished, one vertical, the other almost flat. The gold which is free on the surface is mostly confined to the latter series of veins. One mile northward is the Polita mine in limestone. The deepest workings show a soft, decomposed ore, rich in hydrated iron oxides and containing but little quartz. Two miles farther on are some small veins in slate with the usual quartz gangue and sulphurets. Four miles north of the Polita mine there are several veins in slate. One, the Southern Bell, extends east and west across the strike of the slates. The ore is very similar in character to that of the Polita, showing much iron oxide and little quartz. Six hundred feet farther up the mountain in the same slates there are two very small but rich veins with the usual quartz gangue and iron and copper pyrites.

The Mabel mine comprises several bunchy veins of granular quartz in limestone. It lies three miles north of that last mentioned. The ore is free milling, but stained with iron oxides. No iron pyrites are present on the surface.

The Sacramento terminates this belt of mines on the north. Here is a vein in granite dipping less than 30 degrees. The quartz is hard but honeycombed, and from the amount of iron pyrites and chalcopyrite present it is judged that there will be found but little free gold with depth.

In the mountains west and southwest of Benton there are many gold bearing quartz veins. As a rule the gold is associated with pyrites and other minerals, which makes its extraction difficult. In some mines there is a notable quantity of galena and other silver ores. The country rock is granite.

A large number of gold bearing quartz veins are found scattered along the scarp of the Sierra Nevadas near Mono lake. These are mostly in metamorphosed sedimentary rocks. The most important mine is the Golita where there is a body of ore 50 to 70 feet wide, lying between limestone and a porphyry-like rock. Gold and silver both occur here in nearly equal proportions. More iron pyrites is being encountered in the deeper workings and it is probable that the free gold will entirely disappear with depth. It is not definitely known in what manner the silver is combined. The deposit appears to be chiefly an impregnation of the acid porphyry. A vein of copper carbonate separates the gold and silver ores from the limestone.

A very interesting group of gold mines is that on mount Scowdan, south of Mill Creek cañon and near the summit of the Sierra Nevadas. This mountain rises to a hight of 11,500 feet, being composed of granite except on the northwest where there are bodies of quartz porphyry and silicious metamorphic rocks. The mountain is seamed by quartz veins on three sides. Some stand vertically on its very summit, while others outcrop on the steep cañon walls, dipping in at an angle of 30 degrees or less. While the greater number and more regular veins are in granite there are some in the porphyry and metamorphic rocks. The ore from all the veins in the granite is quite similar. The gold is found free in the superficial workings together with a little galena. In the deepest workings of the May Lundy mine the free gold disappears and its place is taken by iron pyrites. Next to Bodie, this is the most important gold district east of the Sierra Nevadas.

A number of small veins are found in the low granite hills north of Mono lake. Iron pyrites is abundant, as was universally found to be the case with veins in granite. These veins are generally quite flat.

Bodie has been the great centre of gold mining in eastern California, more than $20,000,000 having been produced here. The gold bearing veins are unique in many respects. Their period of formation followed the volcanic activities of Tertiary time, and in age as well as general character they differ markedly from the other important gold deposits of California. The inclosing rock is hornblende andesite, which covers an extensive area north of Mono lake and seems to belong to the same period of eruption as the andesites along the summit of the central and northern Sierras. The most important thing about the Bodie ores is, however, the fact that the veins ceased to be profitable below 700 feet. The mineralized zone, containing a large number of quartz veins within a width of 400 feet, extends nearly north and south for about two miles, but has been profitably worked only along the northern portion. The veins are divided into two classes, an older easterly dipping one, and a younger, nearly vertical or inclined at a high angle to the west, one series faulting the other. The veins of the Syndicate mine on the north are beautifully banded, with the appearance of having been formed in open fissures by successive layers from the walls inward. They became unproductive at a depth of 250 feet. The Standard mine next south shows a still larger number of veins, varying from exceedingly thin seams, which are very rich, to an extreme width of 90 feet. The latter vein has an average width of 20 feet according to Whiting and constitutes the most important ore body. Mr. Whiting* considers these veins "to have been in part a filling of open fissures, in part a gradual replacement of thinly sheeted country rock between the principal structural planes of fractured zones by the vein forming minerals once held in solution." In the Standard mine the veins became smaller and almost barren below the 500 foot level. In the Bodie and Bulwer mines on the south the ore bodies extended to a somewhat greater depth. The Fortuna, the greatest of the older veins of the Bodie mine, became un-

*Eighth Report of the Cal. State Mining Bureau, p. 338.

profitable below 700 feet, where it broke up into stringers with a heavy seam of clay. The greatest depth reached in the mines of Bodie is 1,200 feet, but no profitable ore was found, the biggest veins being replaced by fractured rock and clay. According to Whiting, native silver was found in seams of the rock adjoining some of the veins, while pyrites and silver ores occur in small amounts. The ore from this district is all free milling, even at the greatest depths worked.

It is evident that since the solfataric action took place along this crushed zone but little erosion has occurred and the superficial character of the ores is for that reason all the more remarkable. Although no such depth has been reached in the other gold mines of eastern California there is no reason to believe that they differ from the common type of the rest of the state. The comb structure of the quartz and the pronounced banding of a large number of the veins of this district suggest strongly the presence of more or less open fissures during ore deposition.

Argentiferous Galena.

Important deposits of argentiferous galena have been worked at Cerro Gordo, Darwin and Modock in Inyo county. The ore occurs generally in limestone in chamber form, although occasionally it assumes a vein-like character. The Modock mines on the eastern slope of the Argus range illustrate well the characteristic manner of occurrence. A great thickness of limestone forms the eastern slope of the Argus range between Darwin and Modock, and in many places it has been more or less mineralized, as shown by the bright yellow and red surface tints. The Modock mines are situated on a hill one half mile in diameter terminating a spur of the range. The central portion of the hill is filled with chamber deposits of galena rich in silver. These are scattered in such an irregular manner that no systematic method of development can be undertaken. Some are found by following minute stringers of ore or slightly mineralized country rock, while others are located by chance. The hill has been opened to a depth of 1,150 feet, at which level the richest ore was found.

The Defiance mine at Darwin consists of a series of irregular chambers between granite and calciferous quartzite. Much iron oxide is present in addition to the galena. Considerable gold is frequently found with the iron. The Sorba mine lies wholly in limestone, but the character of the ore is very similar. This mine, together with some others north of Darwin, has a fairly well defined vein form, although quite irregular.

In the description of these silver mines no attempt will be made to enumerate the various complex ores resulting from surface alteration, ores very similar to those of other silver districts of the west.

The silver-lead mines of Cerro Gordo, situated near the summit of the Inyo range, have produced several million dollars. The Union mine was opened to a depth of 900 feet, when the ore body was lost. The inclosing rock is limestone of Carboniferous age. Bunches of very rich gold ore were occasionally found in this mine. Quartz occurs in some of the deposits about Cerro Gordo. When this gangue is present the lead content is less important, being replaced by iron and copper sulphides.

The silver-lead ores of this region have been formed, without doubt, chiefly through replacement. Although a certain amount of fracturing and crushing of the country rock, giving an opportunity for the passage of solutions, must be admitted, yet in the strict sense of the term they cannot be termed veins or fissure deposits.

In exceptional instances important bodies of galena occur in well defined veins, the gangue of which is part quartz, associated with sphalerite, bornite and antimonial copper ores. This character is best illustrated in the mines of Blind Spring hill near Benton, where occur many small but rich veins in granite. Galena is abundant here but is not as rich in silver as stromeyerite and tetrahedrite. The veins are regular and persistent. Several of them dip at a very low angle.

Silver Bearing Sulphides of Copper, Antimony and Arsenic.

These minerals are found in well defined veins, seemingly without regard to the character of the formation. Over much of the area in question they are frequently associated with gold bearing quartz veins, the value of the contained gold sometimes equalling or exceeding that of the silver.

About the town of Panamint this class of ores occurs almost exclusively. Stromeyerite and tetrahedrite with decomposition products are the most common. Galena is rarely found. The veins appear in all the sedimentary formations of the district, namely, limestone, quartzose rocks and schists. The gangue of the veins is quartz, while their fissure character is pronounced.

A similar class of ores is found in the Wild Rose district in the northern end of the Panamint range. The deposits are scattered over a large extent of country to the almost total exclusion of galena and gold. In their distribution they seem to bear no relation to the mineralogical character of the country rock.

The character of the deposits in Blind Spring hill, southern Mono county, has already been referred to. Although there is much galena in some of the veins, the rich ores are stromeyerite and tetrahedrite. Over $4,000,000 has been produced here. The hornblende granite within the area of a square mile has been badly fractured with the formation of veins running in several different directions.

The silver deposits of Alpine county were formed subsequent to the volcanic activity of Tertiary time. A part of them occur in andesite tufas and a part in the more ancient crystalline rocks. About Monitor the lavas have been subject to the energetic action of mineralizing agents, as shown by the extensive areas with brilliant red and yellow surface tints. Enargite is the rich silver bearing ore in this district, occurring in somewhat bunchy deposits with iron pyrites, marcasite and occasionally galena and sphalerite.

Pyritiferous Mineralization of the Rocks of Eastern California.

A most striking feature of this region is the wide distribution of iron pyrites, its presence being recognized at a distance of many miles by the red stains on the rock faces of the mountains. Along the mineral belt between Modock and Darwin the limestones are more or less stained by iron oxide for many miles. The Panamint range, and especially its northern portion, has been subject to intense dynamical action, a fact revealed by the crushed condition of the strata. This is well illustrated in Wild Rose cañon, where the rocks break up into a fine rubble. A red color of varying degrees of intensity characterizes these rocks over large areas. This is due to minute crystals of pyrite thickly disseminated through the rock. A careful panning of the decomposed material from various places in the beds of the cañons failed to reveal any traces of gold.

A similar impregnation is shown by the quartz porphyries which appear for several miles along the El Paso range, a spur of the Sierra Nevadas in the Mojave desert. Granite occurs extensively in this range about 20 miles northeast of Mojave. A portion of this granite, perhaps 1,000 feet long and several hundred wide, has been mineralized, as shown by its reddened surface, the color coming unquestionably from iron pyrites. A panning of the decomposed surface showed the presence of a small amount of gold.

For many miles portions of the western slope of the White Mountain range show reddish tints mingled with yellow due to the original presence of iron pyrites, for the wash from the cañons leading into the mountains contains quartzite and other acid rocks filled with iron pyrites.

The eastern slope of the Sierra Nevadas shows the same phenomenon for nearly 100 miles. The more important pyritiferous areas are confined to the acid porphyries and the highly metamorphosed quartzose schists and slates. They begin with a belt of metamorphic rocks west of Round valley, near Bishop creek, and give a most striking appearance to the mountains in many places as far north as Alpine county. The pyrite seems to be distributed through the rock, the granite often excepted, in the most indiscriminate manner. It is particularly noticeable about Convict lake and in the Castle Peak region.

The barren slopes of the Sweetwater range in northern Mono county show the characteristic red and yellow tints visible for a long distance. An examination of the formation in Ferris cañon shows it to be a light colored acid rock possessing a porphyry-like aspect and filled with small crystals of iron pyrites.

No detailed study has been given to the question of the origin of the iron pyrites. To the writer it seems that it must be of secondary origin and that it is related to the widely disseminated deposits of the precious metals. Its presence in the ancient acid eruptives as well as in the most of the varieties of the sedimentary rocks would seem opposed to the view of its primary nature. On the contrary its distribution through large areas of massive rocks, as well as the fact that in its distribution it generally seems to be independent of known ore bodies, is rather difficult of explanation on the view of secondary origin.

Discussion and General Conclusions.

(*a*) *Gold Ores.* A description of the gold quartz veins of California has recently been given by Mr. Lingren.* The writer agrees with most of the conclusions reached in that paper, but in some respects they do not all apply to eastern California. For example he states† that "the gold quartz veins throughout the state of California are closely connected in extent with the above described metamorphic series,and that the large granite areas are almost void of veins,though fissures and fractures are not absent from them." The granite areas of the region described contain the greater number of the gold bearing quartz veins, and they are by no means insignificant in number or value. Lingren‡ also says, "It appears to be a fact that veins in grano-diorite contain more sulphurets than those in other rocks." This is fully borne out by the writer's observations. A statement of general application can be made to the effect that the veins in the granite contain but little free gold below a certain depth, dependent upon local conditions, where it is replaced by auriferous iron pyrites. The veins in other rocks often contain free gold. This is notably the fact in the case of the ores at Bodie and in the White Mountains east of Bishop creek. The gold bearing veins in the limestone near Post Office springs contain a large amount of sulphurets, thus closely resembling the veins in the granite. That the veins in all the different formations are of fissure origin is unquestionable; they are not segregated, nor in any case does the ore seem to have been leached from the walls. There can be no question also, at least as far as the gold ores are concerned, that the mineralogical character of the country rock is of no great importance, the influence exerted being more often dependent upon physical conditions. The instance

*Bull. Geol. Soc. Am., vol. VI, pp. 221-240.
†Loc. cit., p. 239.
‡Loc. cit., p. 231.

might be cited, however, of the vein in the Beveredge district which lost its gold on the passage from granite to limestone, but in other localities of the presence of rich gold bearing veins in limestone. In regard to the occurrence of gold ores on the western slope of the Sierras the writer sometime since expressed views* which are in accord with the observations recorded in this paper, namely, "The character of the mineral deposits depends partly on the nature of the chemical action, the material subject to that action, and partly on the complex chemical conditions in the crushed zone or fissure penetrated by the mineral bearing solutions." It is a fact of general application that certain districts in eastern California are characterized by gold, others by silver, without any marked dependence, except in the case of galena, on the character of the rocks in those districts, that is, gold and silver deposits do not generally occur indiscriminately side by side. This would imply a much greater dependence on the nature of the chemical action than upon the physical conditions existing or the precipitating power of the walls upon the mineral bearing solutions.

A number of the gold mines in the granite have reached a depth of 700 feet without becoming poorer, while those of Bodie have been opened to 1,200 feet. It is only in the latter that the veins have been found to give out, becoming weaker below the 500 foot level.

The occurrence of gold in galena is rather remarkable, as well as that of its dissemination in the granite northeast of Mojave.

It is probable that the gold deposits of eastern California, with the exception of Bodie, are of the same age as those of the rest of the state, posterior to the upheaval terminating the Jurassic.

Mr. Lingren† expresses the following view in regard to the formation of the gold quartz veins of California. "Replacement proper of the minerals of the country rock along the fissure by quartz I have never been able to observe, and cases supposed to be of such nature have always proved to be due to the shattering of the country rock and the filling of it

*Eng. and Mining Jour., vol. LV, p. 200.
†Bull. Geol. Soc. Am., vol. VI, p. 229.

with silica along narrow cracks. The clean quartz usually forming the vein I cannot account for in any other way than by filling of cavities, as it does not seem possible that a replacement of the ferro-magnesian silicates and other minerals could occur without leaving chloritic stains or other signs in the resulting mass." It seems to the writer that the evidences are opposed to Mr. Lingren's views of the presence generally of open fissures, during the formation of the quartz. Veins which are known to have been formed in open fissures almost invariably show a more or less pronounced banded structure, caused by successive additions through a long course of time during which the conditions did not remain absolutely uniform. In an open fissure the deposition cannot be conceived as having taken place except from the wall inward, leaving frequently a cavity in the centre. The best examples of veins which the writer recognizes as having been formed in open fissures are those at Bodie, and at Sulphur creek in the Coast ranges. At Bodie there is in addition to a very regular banding a pronounced comb structure in places. As far as the writer's acquaintance goes with the gold veins of California this sort of banding as well as comb structure is very rare. Emmons says:* "The comb structure of veins on which the early geologists founded their theory that a vein was necessarily the filling of a pre-existing open cavity, is of comparatively rare occurrence." It is not denied that cavities were abundant, for the presence of empty spaces lined with crystals is evidence of that, but that is far from demonstrating the presence of open fissures. The removal of material from the crushed zone by the mineral solutions may not always have been accompanied by substitution at all points, owing to unfavorable physical or chemical conditions, thus giving rise to local chambers lined with drusy crystals.

The ribbon-like quartz so frequent along the Mother lode shows indeed a banded structure, as its name indicates, but of a different kind. It may have been formed by successive additions to the vein on the outside, the streaks or layers of chloritic matter indicating successive tightening of the walls, alternating with their loosening and removal and the accompanying more rapid accumulation of quartz. Emmons† sug

*Am. Inst. of Min. Eng., 1886, p. 133.
†Am. Inst. Min. Eng., vol. XVIII.

gests the following theory for this phenomenon: "The evidence of faulting and of the thin sheeting of the country-rock is there so clear that the explanation at once presents itself, that this appearance arises from the fact that the deposits are partly a filling in of interstitial spaces and partly a replacement of thin sheets of country rock—."

To the writer it seems more probable that instead of open fissures the process began with a crushed zone. That the vein matter was deposited as the solutions removed the crushed material, leaving at no time large empty spaces comparable in size to those now occupied by the great masses of quartz frequently met with. When large bunches of massive quartz occur 20 to 40 feet thick it seems incredible that merely faulting should have left empty spaces of such magnitude at the great depth at which they must have been formed. It seems more reasonable that the amount of crushing was greater in some places than in others, owing to divergent or intersecting fissures, allowing freer access of the mineral bearing solutions and a consequent more complete removal of the crushed matter. The fact that most well defined fissure veins show a seam of clay between the quartz and the wall points plainly to the line along which additions to the vein must be made. Emmons* remarks again that "Ore deposits are to a large extent the actual replacement of the country rock by vein materials and that the filling up by those materials is rather that of interstitial spaces than what might properly be considered open cavities."

The frequent great regularity of the walls of fissure veins, especially along contacts, might be considered as an argument against this view, but it is rare that both walls are regular and the replacement would naturally be largely confined to the one more easily fractured and penetrated by the solutions, as in the veins between diabase and slate. Where extensive orographic movements are taking place the irregularities of the fissure must be more or less planed down, resulting in a mass of clay and broken rock, and that only in exceptional instances could the strain be such as to open and maintain fissures five to twenty feet wide and hundreds of feet in extent during the protracted interval necessary for the deposition of the

*Trans. Am. Inst. Mining Eng., vol. XVI.

quartz. The shattering of the country rock along a fissure and the substitution of silica seems to the writer to absolutely demand the removal of some of the crushed mass. If the removal of any material is admitted it is impossible to limit the extent to which the process might be carried under favorable circumstances. The occasional presence of large bunches or chimneys of quartz along the course of a vein and the frequent slight divergence of short veins from this into the country rock point to local conditions favoring more energetic action.

In many districts the quartz veins are quite localized. On the theory that the lenses of quartz along a vein are due either to an opening of the wall or to movements bringing two concave portions opposite, it cannot be conceived why quartz veins are frequently of so limited extent longitudinally.

Faulting is a very common phenomenon in disturbed regions, but quartz veins or mineral deposits of any kind occur only here and there, so that it would seem that in addition to the formation of fissures there must accompany it in the local centres of deposition more or less removal of crushed rock.

It can hardly be disputed that the large bodies of manganese, chrome iron and quicksilver in the Coast ranges, as well as the galena ores of eastern California, have been formed by replacement.

In this discussion the writer does not wish to be understood as arguing that open fissures have not at times played an important part in mineral deposition, but that there are many reasons against that view of the origin of the most of the gold quartz veins as well as the other mineral deposits of California.

(*b*) *Silver Deposits.* Silver bearing galena is more often found associated with limestone in irregular chamber-like deposits along mineralized zones. Exceptionally it occurs in other sedimentary rocks and in granite, in the latter case forming well defined veins. Calcite and iron oxides form much of the gangue.

Enargite is found only in the Tertiary lavas and more ancient rocks of Alpine county.

Tetrahedrite,bornite,chalcocite, chalcopyrite,and stromeyerite occur characteristically in well defined veins with quartz gangue and in many different formations. It has not been demonstrated that the silver ores are superficial. In the Modock mines the best ore is said to have been obtained at a depth of 1,150 feet. The great body of ore at Cerro Gordo has apparently been worked out but the exploration is said not to have been thorough.

NOTE ON THE DISCOVERY OF A SESSILE CONULARIA.—ARTICLE I.

By R. Ruedemann, Dolgeville, N. Y.

(Plates VIII and IX.)

In collecting, in a layer of the lower Utica shale, problematic filiform fossils to which Prof. J. M. Clarke had directed the writer's attention, a *Conularia* was found to which are attached several smaller cuneiform fossils by organs which at first sight appear like rings. A thorough search in the locality has furnished four more specimens of *Conularia* which bear such appendages; also a few impressions of shells of *Trochonema* to which were attached in one case a single individual of the supposed *Conularia* (pl. IX, fig. 1), and in another case many, but mostly poorly preserved, remains of *Conularia*; also the ever present *Diplograptus foliaceus* Murch. sp., and the above mentioned *problematicum*, which will be described later.

That the *Conulariæ*, their cuneiform appendages and the similar larger bodies attached to shells of *Trochonema* belong together, is a supposition for which this note is intended to submit the arguments.

The *Conulariæ* to which the supposed young are attached (pl. VIII, fig. 1, in which the interior cast of the shell is partly seen), as well as those found without the young in the same layer, compare best with *Conularia gracilis* Hall.* This form was described from the shaly upper part of the Trenton limestone near Middleville, N. Y., while the specimens of the writer's collection were found in the lowest Utica shale.

One specimen (pl. IX, fig. 5) has been figured on account of its remarkably well preserved ornamentation and the structure of the angular grooves. It expands more rapidly than the others, the average angle of which is only 12°. A

*Pal. of New York, vol. I, p. 224, pl. LIX, fig. 5, 1847.

specimen with a length of 14.3 cm. has an angle of 11°. The specimen illustrated rests on one edge. This, however, is not the common mode of compression in this species, for the great majority of specimens apparently show only two angular grooves and one face of the pyramid, because the whole shell has been compressed into the face on which it originally rested. According to Holm* this mode of compression is found with *Conulariæ* of quadratic section, while those of rhombic or rhomboidal section are compressed in the direction of the obtuse angles. The shell of *C. gracilis* Hall, which I have seen only strongly compressed, therefore probably had equal faces and a quadratic section.

The complete flattening of the specimens without breaking, as well as the common bending of the proximal parts of the shell (pl. VIII, fig. 4), are indications of a slight flexibility of the shell. Hall's type also was "slightly bent or arcuate." This remarkable character of *C. gracilis* is causally connected with the extreme thinness of the walls already observed by Hall. As the observation of small wall fragments (pl. VIII, fig. 6) and the abundance of smooth casts of *Conulariæ* indicate, the wall was very easily destructible. This may also account for the frequent absence of wall remains in the young *Conulariæ* while the edges are preserved. Plate VIII, figure 4, and plate IX, figure 5, well illustrate this breaking out or dissolving of the walls between the edges in even larger individuals.

The sculpture consists of "sharp, undulating, transverse striæ and scarcely conspicuous longitudinal ones." (Pl. IX, figs. 5 and 6.) The finer longitudinal ribs alone, however, are continuous and the wavy cross ribs connect with them. Although the latter sometimes unite to continuous and very prominent cross bands, their whole appearance is such as to suggest that they are wrinkles of shrinkage. The undulating transverse and the finer straight longitudinal ribs are so characteristic a feature that they can safely be used to distinguish this form from *Conularia trentonensis* Hall, *C. hudsoni* Emmons and *C. quadrata* Walcott, which have straight and continuous transverse ribs. The undulating transverse ribs are of special importance in the study of the young *Conu-*

*Sveriges Kambrisk-Siluriska Hyolithidæ och Conulariidæ; Sveriges Geol. Undersökning, Ser. C, No. 112.

lariæ, as they are easily recognized by their characteristic form whenever the surface film is sufficiently preserved, however delicate it sometimes may be.

The cast of the interior often shows, in different parts of the same specimen, either the filling of the transverse ribs as similar ridges, or pustules (cf. pl. VIII, fig. 1), and deep furrows in place of the longitudinal r bs, or only the latter; or in many places the cast is perfectly smooth. The last fact is accounted for by specimens similar to that represented in plate VIII, figure 4. This interesting young *Conularia*, which at the distal end shows the straight sulcate edges of a *Conularia*, has in the middle part preserved the wall which consists of two layers,—an exterior deep black, apparently carbonaceous one, which shows the characteristic ribs of *C. gracilis*, and a much stronger inner layer which has a more grayish, mineral appearance and is probably richer in calcium phosphate. This second layer in the middle part between the two upper grooves, where it is apparently least crushed, is almost smooth with only an obscure indication of transverse lines of fracture. On the sides it is broken into transverse ring segments. Although it is thicker than the outer layer, it is more frequently lost, leaving, however, a smooth cast.

The segmental line appears as a shallow groove, scarcely conspicuous in most specimens. It therefore is of no help in identifying the young *Conulariæ*. Of greater importance in this regard is the structure of the grooves at the edges of the pyramid, as this is generally the best preserved part of the fossil. In the specimens, for instance, represented in plate VIII, figure 4, and plate IX, figure 5, the side walls of the grooves alone are preserved in the distal part, the connecting wall being either dissolved, as indicated by the smooth surface between the edges in plate VIII, figure 4, or broken away as in plate IX, figure 5. The walls of the grooves are much thickened, this strengthening extending also to the adjoining parts of the faces, so that the grooves are lined by two thick ridges. The connection between fragile thin faces and stout edges seems to be found in other species also. *Conularia linnarssoni* Holm* f. i. is described as having the grooves stronger than the segmental line and being fragile toward the aperture.

*Op. cit., p. 130, pl. IV, figs.38-40.

As the original of plate IX, figure 5, shows at the upper groove, and as has been observed in other species, the surface film extended—here with its wavy transverse wrinkles—over the groove, covering and closing it (pl. IX, fig. 2, *a*). Where the outer layer is lost, but the underlying parts are fully preserved, there appears next below a thin smooth layer (b) with indications of transverse lines of fracture; this layer in its turn covers a milky white laminated substance (phosphate of lime). The latter (*c*) fills the groove and contrasts strongly with the black shining walls (*d*). Often, however, this substance is lost, leaving the groove empty or giving place to a filling by iron oxides. The side walls of the empty groove show mostly very marked transverse fractures with upturned margins. The groove seen from the inside (pl. IX, fig. 3) has a roof-like form with strongly slanting sides, which are either smooth or exhibit the same transverse joints as seen from the outside. Sometimes oblique pressure caused these joints to be pushed over each other. Where the top is broken off the white phosphate of lime appears again.

From these observations it may be stated that the edges of the pyramid of *Conularia gracilis* Hall formed a kind of supporting framework for the faces; that the grooves, therefore, had strong walls which were continuous with the second mineral layer; that the grooves were filled with phosphate of lime and covered by the sculptured outer layer with an underlying thin film similar in appearance to the second layer. The groove, therefore, appears to be altogether an expansion of the second layer of the wall. A diagrammatic section of the groove at the angle of *C. gracilis* is given in plate IX, figure 4.

The reasons which the writer has for regarding the cuneiform appendages of *C. gracilis*, and the bodies attached to *Trochonema*, etc., as remains of young individuals of *C. gracilis* are as follows:

1. Wherever an appendage is preserved completely it shows four divergent grooves, such as would form the edges of a pyramid, with about the same angle as the older shells of *C. gracilis* (pl. VIII, figs. 2-3, pl. IX, fig. 1). Some apparently show only three grooves, but investigation will generally bring out the fact that the fourth is divergent from the plane

of the others and hidden in the matrix. Generally, however, the whole fossil appears only as a cuneiform film between two thick edges, which are formed by two coinciding grooves, while the two originally vertical faces have been folded inward between the horizontal ones or partly bulge out from between them (pl. VIII, fig. 1, *a*). Some appendages show even only one groove; the proximal parts of the other grooves, however, are also ordinarily traceable into the matrix (pl. VIII, fig. 2). It is to be concluded from this that the complete appendages contained grooves which originally did not lie in one plane.

2. The four grooves show exactly the same structure and composition as those of *C. gracilis*, i. e. the V-shaped section, the filling with milk white phosphate of lime, the extension of the carbonaceous sculptured surface film over them, and especially the very characteristic and easily discerned transverse ridges of the side walls of the groove. (Cf. pl. VIII, fig. 1, *b*, 2, 5; pl. IX, figs. 1, 7.)

3. The space between the grooves of the appendages is generally perfectly smooth, thus indicating that between them was a connecting wall which is now lost. However, in many places the tender carbonaceous surface film is still preserved. Where this is the case the longitudinal ribs, as well as the characteristic undulating transverse wrinkles, are clearly discernible, as indicated in plate VIII, figures 1, 2, and plate IX, figures, 1, 7, at *s*.

4. The carbonaceous cup-shaped bases, by which the supposed young *Conulariæ* are attached to the older individuals, are exactly similar to those of some larger fossils which can be safely referred to *C. gracilis*, and especially similar to the basal cups of the two important specimens reproduced in plate VIII, figure 4, and plate IX, figure 1. The latter, which, on account of its general form, the structure of the four grooves and the sculpture of the surface film, must be regarded as identical with, or very closely related to *C. gracilis*, has a beautifully preserved cup of the same size and structure as those attached to the original of plate IX, figure 2.

5. Finally, it may be adduced as an additional argument for the similarity of the observed appendages and the shell of a *Conularia*, that in some of the former (cf. plate IX, fig. 1, *c*)

a triangular subcarbonaceous plate is preserved which is strongly suggestive of being the flattened apertural process of the uppermost face.

It is permissible to meet some of the objections which are easily suggested in comparing the appendages with *Conularia*. There is first the strangely curved form of many of the smaller and medium sized individuals. As already stated, Hall's type, of about two inches in length, is "slightly arcuate." The axes of the older specimens, however, which the writer possesses, as also the axis of the specimen figured in plate IX, figure 5, are always perfectly straight. An examination of the shells of the young *Conulariæ* establishes the fact that the better they are preserved the straighter they are. (Cf. pl. VIII, figs. 1, 2.) Even some of the very smallest *Conulariæ* are straight. This, as well as an examination of such specimens (pl. IX, fig. 4), in which the youngest part only is bent and the older is perfectly straight, leads to the conclusion that the young shells also of *C. gracilis* were straight, but probably more flexible than the more distal parts and perhaps less able to resist the dissolving influence of the sea water. A group of fossils (plate IX, fig. 7) which are attached to the poorly preserved cast of a *Trochonema* shell, on account of the strong distortions of the wedge-shaped appendages, presents appearances differing most widely from those of *Conularia*. In this case the appendages are identical with the leaves of Hall's *Sphenothallus angustifolius*.* The extensive destruction of the faces of the pyramids in both specimens, as well as the very poor preservation of the gastropod, is proof enough of the destructive influences to which they were subjected and which may also have distorted the slender pyramids before they were covered by sediment. On the other hand both contain a sufficient number of nearly straight shells (cf. especially Hall's figure) to warrant the statement that the pyramids were originally straight. The writer's specimen besides exhibits, in several places, well

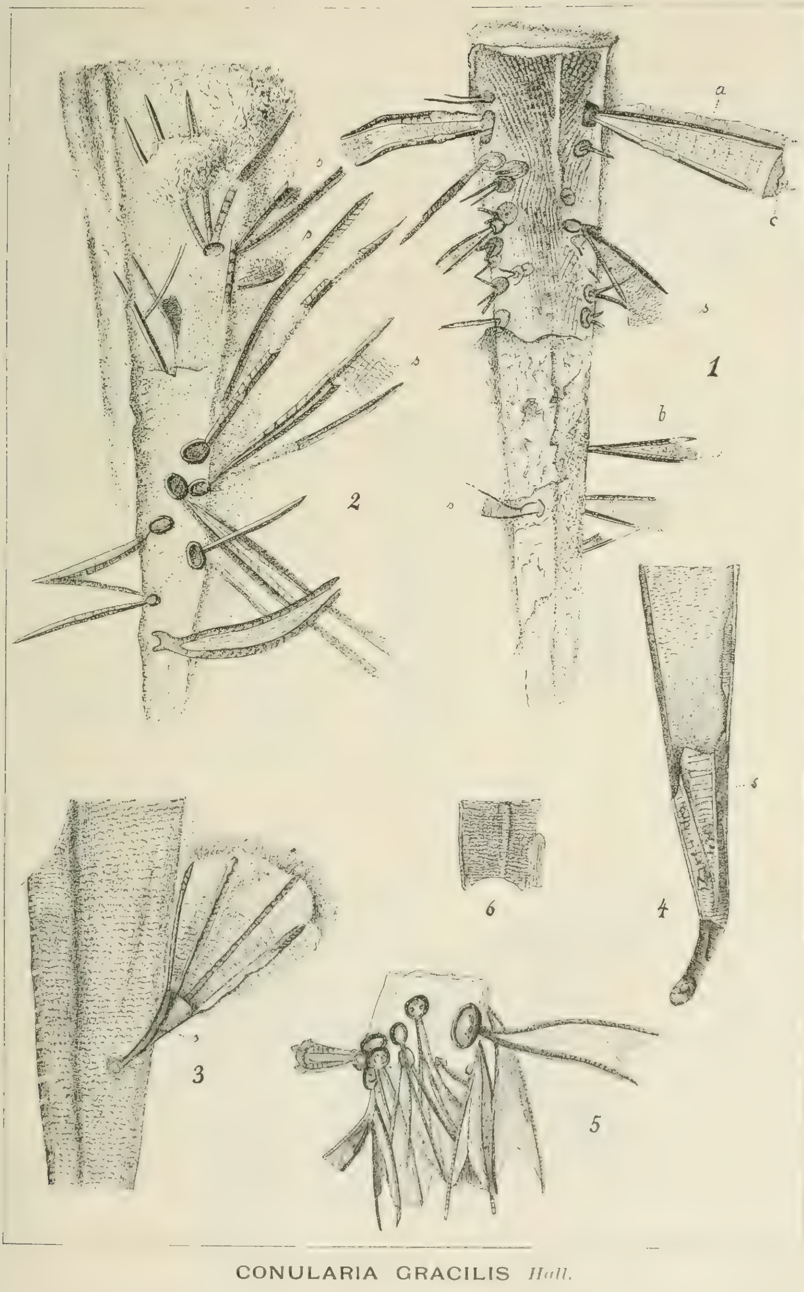
*Pal. of New York, vol. I, p. 261, pl. LXVIII, fig. 1, 1847. Hall's type, which Prof. J. M. Clarke had the kindness to lend the writer and which will be figured again in another paper, not only shows young individuals attached to older "leaves," but also ring-like impressions of the basal cups and the transverse ridges of the grooves. The faces have left smooth impressions only.

preserved transverse undulating cross ribs which are very similar to those of *C. gracilis.*

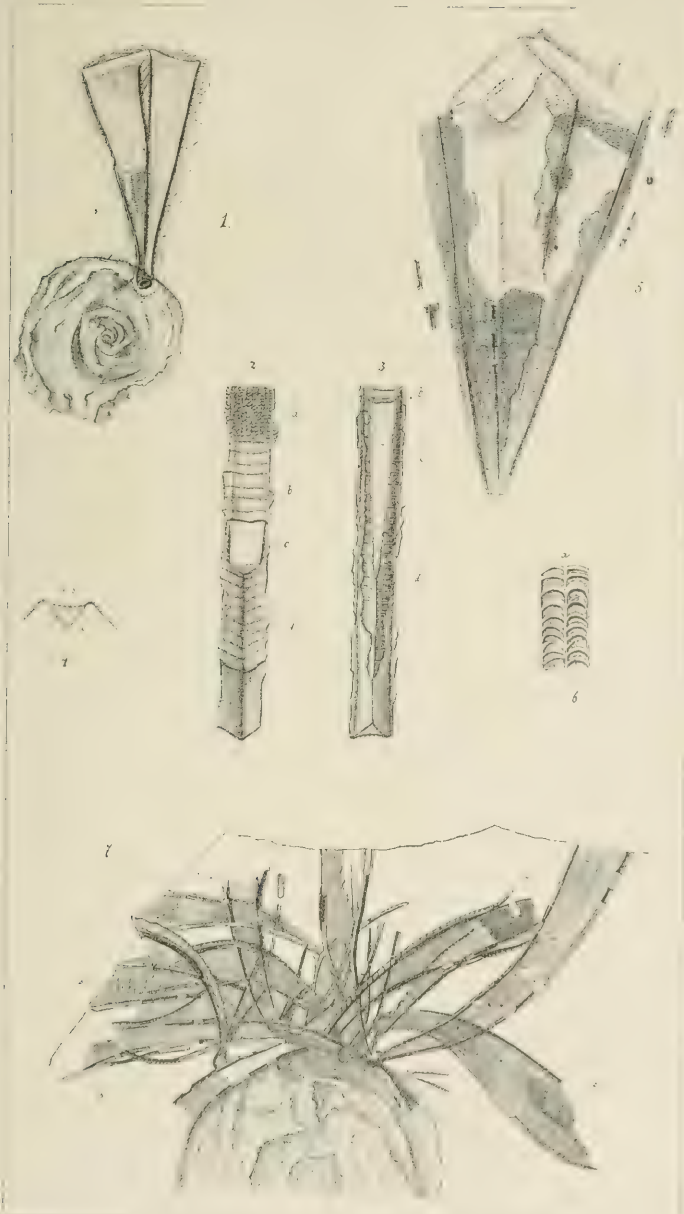
Another objection, which naturally arises in studying these forms, is, supposing that other *Conulariæ* were sessile also, why have not any such bases been found among the thousands of specimens of the species already described? Barrande f. had more than a thousand specimens of certain species without noticing such basal cups in the young, which are generally stouter and better preserved than any other part of the fossil. In almost all described shells of *Conularia* the apex is broken off, either irregularly or along a septum. The irregularly broken shells, which compose by far the great majority, have undoubtedly lost their proximal parts and are therefore not complete and may be considered out of the discussion. Those closed by a septum are most probably not complete either, for as Dr. A. Ulrich* has pointed out, the empty chamber between the imperforate septa must have been more liable to destruction than the other sediment-filled part. It may, therefore, have been lost in most cases, and only that part of the shell beginning at the youngest septum may have been left to us. It remains in the extremely small number of fully preserved shells. Wiman,† on the basis of Holm's paper, estimates their number at less than 5.55 per cent. of all known *Conulariæ.* These few forms again, although tapering down to a very small diameter (the writer does not know of a real "point" having been observed), do not exclude the possibility of having been expanded again into a base. It is true that it does not seem very natural to have a large pyramid supported by such a thin stem, but this was in fact the case with rather large shells of *C. gracilis* (pl. IX, figs. 1, 7). Suppose all *Conulariæ* were attached thus, then it would have been just as strange if the pyramids, in becoming covered, had not been broken right over the bases, as it is that not more of the shells, if they were free, should have preserved the apex. It also bears on this question that several cups, among them one with a diameter of 5 mm., have been found which bear only a very small fragment of the pyramid (several of these will be figured in the

*Palæozoische Versteinerungen aus Bolivien, p. 35, 1892.

†Palæontologische Notizen 1 und 2, Bull. Geol. Inst. Univ. Upsala, vol. II, no. 3, p. 7, 1894.



CONULARIA GRACILIS *Hall.*



CONULARIA GRACILIS *Hall.*

next paper), and that the specimen represented in plate VIII, figure 1, bears a great number of bases from which the young *Conulariæ* are broken off. The preservation of the apex not only forbids any positive conclusion as to the mode of life of the *Conulariæ*, but the supposition of their free existence seems to be questionable and will, therefore, be discussed in another paper.

As none of the large specimens of *C. gracilis* have been found attached, the question as to mode of life cannot be directly answered. It can, however, be remarked that the largest specimen in the writer's collection (length 14.3 cm.) is preserved to a breadth of 4 mm. and ends in a deep impression which could be caused by a cup not larger than the largest well preserved one which has been found. Further, it will be noticed that some of the attached shells (Hall's *Sphenothallus*, pl. IX, figs. 1, 7) have already reached a size which renders it improbable that the enclosed animals should still have changed their mode of life.

Explanation of Plates.

Plate VIII.

Fig. 1. *Conularia gracilis* Hall, with attached young. *a*, wall pressed out: *b*, transverse striation of groove; *c*, apertural process of wall; *s*, sculpture of surface discernible. ×2.

Fig. 2. *C. gracilis*, with attached young. *s*, fragments of sculptured wall. ×2.

Fig. 3. Young *C. gracilis*, with four distinct edges, attached to an older shell. ×2.

Fig. 4. Detached specimen of *C. gracilis*. *s*, surface film. ×2.

Fig. 5. Group of very young specimens of *Conularia* cf. *gracilis* Hall, attached to a shell fragment. ×2.

Fig. 6. *C. gracilis*. Fragment of the wall. ×2.

Plate IX.

Fig. 1. *C. gracilis* on *Trochonema* cf. *ammonius* Hall. Natural size.

Fig. 2. Sulcus at the edge of *C. gracilis*, exterior view. *a*, surface film; *b*, second film; *c*, filling prism; *d*, side walls of groove. ×4.

Fig. 3. The same, interior view. ×4.

Fig. 4. The same, transverse section. ×4.

Fig. 5. *C. gracilis*. Natural size.

Fig. 6. Enlarged sculpture. ×13.

Fig. 7. *Conularia* cf. *gracilis* Hall (*Sphenothallus angustifolius* Hall). *s*, sculpture of surface discernible. Natural size.

[PALÆONTOLOGICAL NOTES FROM BUCHTEL COLLEGE. No. 12.]

A NEW TITANICHTHYS.

By E. W. CLAYPOLE, Akron, Ohio.

(Plate X.)

The fragmentary condition of nearly all the specimens of *Titanichthys* and the other great placoderms of Ohio renders the identification of species a matter of no little difficulty. Without a single complete skeleton for comparison it would be rash to attempt the nominal description of the various plates that are found separated and scattered in the shale. Cases do occur in which the correlation of some parts is possible either with absolute certainty or with a degree of confidence that justifies action. But to name the sundered plates as if they had belonged to different species would be only encumbering the subject with a mass of synonyms and repeating what has already proved a fertile cause of trouble and error in past experience.

In bringing forward, therefore, the many fossils which the labors of Dr. Clark and others have of late years brought to light, I have limited the technical characters of the species for the most part to the mandibles. These are the parts of the skeleton most frequently found and the parts that occur usually in the best state of preservation. Other plates when described are referred if possible to their place in the fish, but only as plates of *Titanichthys* in general.

Thus in bringing forward the present species the same principle is adopted and though several other plates are known, being contained on the same slab, yet the essential characters will be based in the first place on the mandibles.

The fossil in question is one that was found by Dr. Clark about two years ago in the same region which has yielded him so many other treasures of a similar kind. It is considerably broken and consists of ten or more fragments fitting together with fair accuracy. Weathering along planes of natural jointing prevents their close union. On this slab and its counterpart lie compressed and considerably disarranged the plates of the head of a small *Titanichthys* and the anterodorso-laterals or supra-scapulas that were in life locked to it by the well known socket-joint. Few of these plates are perfect, but fortunately the mandibles have been so well exposed by the careful work of the discoverer that they suffice to characterize the species as different from all that have been hitherto described.

These mandibles are minute compared with those with which the name has been usually associated, showing that the genus included species ranging widely in size. Their length is only five and a half inches. One of them, the left, is represented in plate X. It has the spatulate hinder end that marks all the kindred forms, but the front is much thicker and less pointed than in either *T. agassizi*, *T. clarki*, *T. rectus* or *T. attenuatus*, the only other species yet known. No teeth have been found, but the socket or channel in which they may have been set is clearly marked and extends along about one inch and a half back from the tip, being scarcely more than one quarter of an inch deep. The greatest depth of the jaw is about one inch from the point and here it does not exceed three quarters of an inch. The outer wall of the alveolus or channel is, as in the other species that show it, higher than the inner. The mandible is scarcely one fourth of an inch in thickness at its maximum, which occurs at the point of greatest depth, and from this it thins away in both directions.

The above details are amply sufficient to characterize this new species, which in consequence of its relatively smaller length and the bluntnesss of its anterior extremity I propose to name

TITANICHTHYS BREVIS.

But as mentioned above, the slab shows several other plates whose connection with the same individual is beyond question. Some of these are represented in the main figure and others on the reduced diagram of the head (plate X). The supra-occipital, the exoccipital, the large marginal, the frontal and the post-orbital can all be distinguished on the chief specimen. Some of them present the inner and others the outer surface, having been somewhat displaced before fossilization took place.

A second specimen, showing only the inner face of the cranium with somewhat less displacement of the corresponding plates, confirms the details gathered from a study of the first; and the diagram of the head has been compiled from data obtained from both specimens.

The antero-dorso-lateral plate is in an excellent condition to show the tenon in its almost vertical position with perfect distinctness. The socket for the reception of the tenon is also preserved in the left exoccipital, the only one visible. The outline of the posterior part of this plate, the supra-scapula, is somewhat restored and may not be quite true to nature.

In the second specimen the parietal on the left side is well shown in connection with the supra-occipital and the marginal plates on both. The outer border of the post-orbital can be traced, outlining the cavity for the eye.

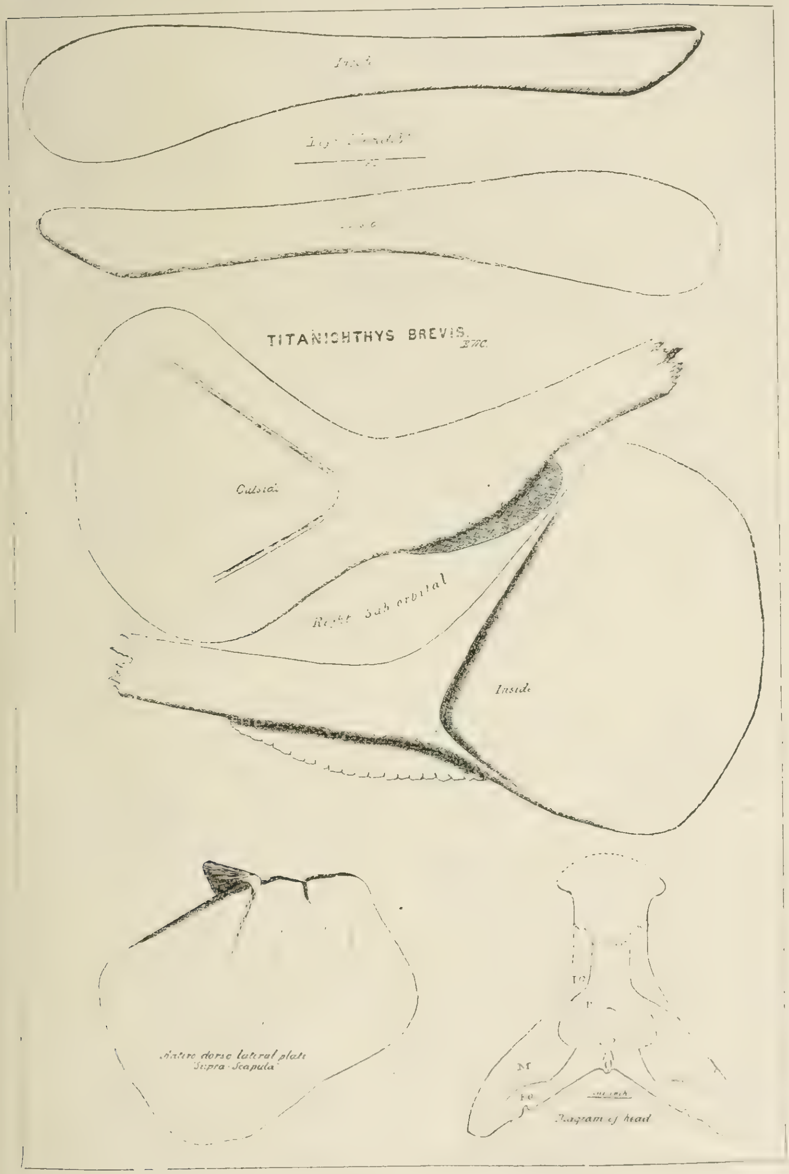
The point of the head is distinct and its heavily pyritized condition suggests the probability that it was largely cartilaginous, a supposition which is borne out by the similar state of the crania of some of the other species of *Titanichthys*.

The fore part of the cranium was apparently very narrow so far as its osseous portion was involved, but it may have been extended below or outside of the orbits with cartilage.

The sub-orbital or maxillary plates are both preserved and are reproduced in plate X, both inside and outside. The strong shoulder for the support of the great shear-tooth is visible and in the outside view the shear-tooth itself may be seen. It still lies in its place in the bone of the right side. The inside figure in the plate is for convenience taken from the left sub-orbital reversed.

One other point deserves a passing word, though more as a curious fact than for any valuable deduction that it can furnish. In the hollow of the left sub-orbital plate and exactly in the spot where the eye was situated lies a roundish mass which, it is scarcely doubtful, represents the eye itself. No details can be made out. It is simply a mass of crystallized pyrites resembling that which has replaced the snout of the fish, but its position and form render the origin here suggested the only probable view.

So small a species of *Titanichthys* as the one represented by the plates here figured cannot have been a very formidable inhabitant of the waters of the Appalachian sea. Whatever its dentition may have been, it must have been quite defenseless beside its greater congeners, omitting all mention of the dinichthyids. No evidence regarding the food of these species of fishes has yet come to light. Their plates are always found



A NEW TITANICHTHYS.

detached and the soft parts have left no trace, whereas the tougher skins of the cladodont sharks in the same strata have preserved for us not only the forms of the fishes but in several instances the contents of their stomachs, giving ample proof, if such proof had been necessary, of the nature of their prey.

THICKNESS OF THE PALEOZOIC ROCKS IN THE MISSISSIPPI BASIN.

By Charles R. Keyes, Jefferson City, Mo.

The thickness of the Paleozoic strata of the central Mississippi basin has been variously estimated. With a single exception the calculations place the number somewhere between 4,000 and 6,000 feet, or in the neighborhood of one mile. The figures obtained of late years have tended to reduce considerably the earlier estimates; and the most recent information goes to show that even these are still somewhat excessive. The chief discrepancies in the various estimates are to be found in the Carboniferous and in that portion of the geological column below the Trenton, which is one of the best marked horizons in the region. There is close agreement regarding the vertical measurement of the median portion, the Devonian and the upper part of the Silurian. Tabulated the various figures are as follows:

Date.	Name.	State.	Total.	Coal M.	Below Trenton.
1855	Swallow	Missouri	4,200	600	1,400
1858	Hall	Iowa	3,400	1,000	800
1866	Worthen	Illinois	4,300	1,200	300
1872	White	Iowa	3,800	800	700
1893	Keyes	Iowa	2,700	1,600	600
1894	Broadhead	Missouri	5,500	2,000	1,300
1894	Keyes	Missouri	4,100	1,600	700
1895	Norton	Iowa	3,500		
1895	Keyes	Missouri	3,000		

Stratigraphically the territory west of the Mississippi, covering an area somewhat larger, but approximately of the same shape as the Western Interior coal field, is a broad shallow basin. Its margin sweeps in a wide curve from west-central Minnesota to the southeastern part of that state, through southwestern Wisconsin, western Illinois, across central Missouri into Indian Territory. The center or lowest portion is probably not far from where the Iowa-Missouri boundary line intersects the Missouri river. The marginal rocks are chiefly

Silurian; those of the center are much younger. In Iowa the general dip of the strata is towards the southwest. The degree and remarkable uniformity of the inclination has recently been determined by Norton** for the northeastern half of the state. The results are especially reliable for the reason that the inquiry was undertaken for the purpose of determining the artesian water horizons; and the chief water-bearing stratum, the St. Peter sandstone, is easily traceable over the greater portion of the area on account of the numerous deep wells put down. In northeastern Missouri the dip is nearly west; and from the Ozark uplift northwestward. The place in which it would be expected that the Paleozoic rocks would show a maximum thickness, that is, the middle part of the basin, is in the neighborhood of the Missouri river between Kansas City and the Iowa boundary.

The variation in estimates of the thickness of the stratified rocks below the base of the Trenton is as great as 1,100 feet. In Missouri, Swallow* and Broadhead† agreed in a measurement of about 1,400 feet. Other figures‡ which were based chiefly upon observations in the Iron Mountain region placed it at about 650 feet. It is quite probable that the latter number is considerably too small when the region in general is taken into consideration, and that a mean, or about 1,000 for the state, would more nearly harmonize with the actual facts. Worthen§ allowed less than 300 feet for the same succession, but this manifestly only referred to the outcrop as shown in Illinois. In northeastern Iowa, Hall‖ placed the exposed measurement at a little less than 800 feet; while White¶ ascribed a thickness of about 600. To these figures, for the sedimentaries beneath the Trenton in this part of the basin, should be added about as much again, as was subsequently shown by deep borings. It is quite likely, then, that the lower part of the geological column is somewhat thicker on the northern rim of the basin than on the southern.

**Iowa Geol. Sur., vol. III, pp. 167-210, 1895.
*Missouri Geol. Sur., 1st. and 2nd. Ann. Repts., p. 60, 1855.
†AMERICAN GEOLOGIST, vol. XIV, p. 381, 1894.
‡Missouri Geol. Sur., vol. IV, p. 30, 1894.
§Geol. Sur. Illinois, vol. II, p. 40, 1866.
‖Geology of Iowa, vol. I, p. 42, 1858.
¶Geology of Iowa, vol. I, p. 26, 1872.

With the upper portion of the column the difference in the determinations of the thickness are even greater than in the case of the lower part. In the Coal Measures alone the extremes are 600 and 2,000 feet; the first is White's estimate, the latter Broadhead's. In Iowa the total thickness of the Upper Carboniferous was recently placed at 1,600 feet, of which the Lower Coal Measures were thought to occupy about 400 feet. The result for the latter was based chiefly upon deep well drillings. A very careful calculation* was also made along a line running from the margin of the coal field to the surface outcrop of the base of the upper Coal Measures, the exposures being nearly continuous for a distance of sixty miles. This and numerous other tests in various places shows clearly that the usual method of measuring exposures along a given line and adding them together give unreliable results even under the most favorable circumstances, and without counting any portion twice. The maximum thickness of the Coal Measures in the central part of the basin is therefore considerably less than even the most recent estimates;† and other data soon to be referred to go further to substantiate the statement.

The coal fields of Missouri and eastern Kansas may be regarded as lying on the northern flank of the Ozark uplift. On the southern slope, in western Arkansas and the eastern part of Indian Territory, the thickness is enormous as compared with the more northerly regions, if the estimates recorded are correct. Chance‡ ascribes a thickness to the Coal Measures of the Choctaw field of 8,500 feet; Winslow,§ to similar strata in the Arkansas valley, 10,000 feet; while in the Ouachita district Griswold‖ believes that the columnar section of the Coal Measures and Lower Carboniferous have a thickness of upwards of four miles, or about 21,000 feet. It is probable that all these figures are excessive; yet the strata are undoubtedly very thick, as the recent field work by Stevenson¶ in the same regions also goes to show. It seems probable that

*Bull. Geol. Soc. America, vol. II, p. 286, 1891.
†Missouri Geol. Sur., vol. IV, p. 14, 1894.
‡Trans. American Inst. Mining Eng., vol. XLVII, pp. 653-661, 1892.
§Bull. Geol. Sur. Soc. America, vol. II, p. 232, 1891.
‖Proc. Boston Soc. Nat. Hist., vol. XXVI, p. 476, 1895.
¶Communicated, 1895.

in this area of very marked folding there is another example of great thickness of strata, just as in the Appalachians.

Assumming, as is now believed, that the Coal Measures and Lower Carboniferous limestones were deposited entirely over the area occupied by the present Ozark dome,* which is of very recent origin, the enormous thickness ascribed to the more southerly Carboniferous rocks is as yet devoid of adequate explanation, as is also the derivation of so vast accumulation of sediments over one part of the area, while in so short a distance to the north the beds of the same age are relatively so thin. Branner,* however, has put forth the suggestion of an old continental mass extending through northern Louisiana, but having been base-leveled, was subsequently buried by the soft Cretaceous and Tertiary clastics.

Bearing directly upon the question of the thickness of the Paleozoic strata in the upper Mississippi basin and of the Ozark uplift and furnishing some of the most important information yet obtained, are certain deep borings which have recently been put down at various points in Missouri. Attention† has already been called to these. One at Sullivan in Franklin county, which was begun below the horizon of the Trenton limestone passed through about 1,100 feet of the magnesian limestones and sandstones before entering the granite. Another, at Carthage in Jasper county, was started at about the base of the Coal Measures and encountered the crystalline basal complex at 2,000 feet. The most noteworthy of all, however, is a diamond drill hole sunk near Kansas City, a location that is not far from the thickest portion of the basin of the Western Interior coal field. The top of the well is a little above the base of the upper Coal Measures. The core at the bottom is 1⅞ inches in diameter. The last thirty feet are reported to be in the rock, which examination shows to be a black mica schist, the cleavage planes of which have a dip of 35 degrees. If the natural inferences are correct the entire Paleozoic sequence from the base of the upper Coal Measures has been passed through in a vertical distance of less than half a mile; the schistose floor of the unaltered sedimentaries has been reached in Missouri; and Archean

*Arkansas Geol. Sur., Ann. Rept. 1890, vol. III, p. 283, 1892.

†Missouri Geol. Sur., vol. VI, p. 330, 1894; also ibid., vol. VIII, p. 334, 1895.

rocks are present which are not unlike the more typical areas in other parts of the American continent. Allowing 500 feet for the rest of the upper Coal Measures the total maximum thickness of the Paleozoic at the Missouri river is about 3,000 feet.

With reliable data relative to the thickness of the Paleozoic succession in the various parts of the region the stratigraphical problems become greatly simplified in certain directions; and the ordinary deep wells may be expected to supply facts which were heretofore not seriously considered.

MICROSCOPIC CHARACTERS OF THE FISHER METEORITE (MINNESOTA NO. 1).

By N. H. Winchell, Minneapolis, Minn.

This stone, which fell April 9, 1894, was briefly announced in the American Geologist (vol. 14, p. 389, Dec., 1894) when the circumstances attending its descent were also stated so far as they are of any scientific value.

The stone is covered with a thick brown crust showing the wavy fluidal surface, indicating fusion by the application of heat to the exterior. It is pitted with the usual depressions and prominences. Of the two pieces that fell one was immediately broken up by the farmers, who desired, as they said, to know whether any gold was inside of it. The fragments were scattered amongst them, and some were taken into North Dakota. The other remains entire. That which was broken up was the larger; the smaller one weighs about nine and a half pounds. Several of the pieces of the larger mass have been recovered, and from these this description was written, except as to the exterior appearance, which is described as it occurs on the smaller mass. The coating, however, on the smaller fragments has no noticeable difference from that on the mass preserved entire.*

The specific gravity of the stone is 3.44.

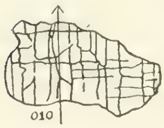
The color is light gray, but flecked with rustiness from oxidation of the iron. The iron is not abundant, but in isolated grains varying in size from a mere speck to 1.5 or 2 mm. in diameter. The broken surface glitters with scattered bronzy reflections, apparently of troilite.

*The mass preserved is in the museum of the University of Minnesota. Several of the pieces of the mass broken up are in the possession of Mr. Geo. Kunz, of New York.

In thin section the stone, aside from the iron elements, appears to be principally a granular mass of olivine, more or less rusted, and of enstatite, showing occasionally the chondritic structure. The olivine seems to have been entirely shattered from its crystalline integrity, and to exist now in the form of more or less angular cleavage and other fragments impacted together and held in place by a secondary cohesion. Still, in general the individual fragments are not far removed from their original positions, and in some instances are sufficiently large to operate on with convergent light between crossed nicols.

The polarization colors are high. Of the numerous sections afforded by the slices some are found perpendicular to the different axes of elasticity. In one perpendicular to *ng* (𝔠) two cleavage systems are distinctly apparent which intersect each other at right angles, although these are crossed by other coarse cracks which cut the grain into many irregular fragments. These cleavages are those parallel to the brachypinacoid (010) and the base (001), the latter being less evident than the former. Extinction takes place parallel to these cleavages.

Another section is cut perpendicular to *nm* (𝔟) and has a bright bluish-green color. It extinguishes parallel to its principal cleavage (010), the other cleavage being reduced, by the shattering which the grains have all suffered, to an irregular series of cross-fractures of the lamellæ 010, hardly continuous enough to be recognized as cleavage. This section is parallel to the base. Other basal sections show no regular cleavage.



Another section, with two distinct rectangular cleavages is perpendicular to *np* (𝔞), which in olivine indicates a section parallel to the brachypinacoid. One cleavage is straight and clear, the other is coarse and somewhat irregular. Extinction is parallel to these cleavages.

There are numerous sections which have extinction at a varying angle with the cleavage, owing to their obliquity with the principal zones.

The chondri are composed of olivine and of enstatite. The various lamellæ consist of many individual granules having a common orientation, and the lamellæ themselves extinguish in unison and frequently parallel to their elongation. Occasionally a granule, not exactly in line with the series constituting one of the lamellæ, but rather between two lamellæ, extinguishes at a different angle. The lamellæ in the olivine chondri are nearly straight and parallel. Between them is sometimes an isotropic substance which is probably glass, but sometimes this substance affords an aggregate polarization. In those olivine chondri in which the lamellæ are cut parallel to 001, that is, perpendicular to the mean axis of elasticity, the distinct cleavages run directly transverse to the elongation of the lamellæ as viewed. Hence the lamellæ are of the nature of plates parallel to 100. Sometimes the lamellæ contain no interlamellar glass, but the alternate lamellæ are differently oriented, there being two directions, with an angle of about 24 degrees between them. Sometimes parts of different chondrules are closely adjacent, each having its independent orientation. In this condition the appearance somewhat resembles the radiating lamellæ of the chondrules of enstatite, and in some of the enstatite chondrules olivine constitutes a portion of the interlamellar mineral.

There are apparently two isotropic substances in this meteorite, one being glass (at least glassy) and the other having a cleavage. The latter is clear as glass in ordinary light, and has refraction approaching that of olivine, as shown by the shagreen which is produced on lowering the condenser. It may be maskelynite, which is a mineral discovered by Tschermak in 1872, isotropic but having nearly the composition of labradorite. Below is a pencil sketch of the aspect of the cleavable grain in common light with the condenser lowered. This indeed is the only grain of the

isotropic substance which I have been able to find showing a distinct cleavage. The non-cleavable substance, appearing like glass, is rather widely distributed, but there is no certainty that they are the same, although the glassy substance seems occasionally to transmit a little light between crossed nicols. The cleavable mineral has occasionally a trace of a second cleavage as represented.

There is this distinction between these isotropic substances. viz., the glassy grains, as appears in the chondrules of olivine where the interlaminations between the lamellæ of olivine are in part of this glassy substance, on becoming crystalline gradually transmit light and *have four extinctions*. But the cleavable mineral when perfectly crystalline is continually dark between crossed nicols. They, therefore, belong to different crystalline systems.

In a consideration of the specific gravities of the principal elements of this meteorite there appears to be reason to look for the presence of a lighter mineral than olivine. Thus:

Specific gravity of olivine	3.30
Specific gravity of iron	7.50
Specific gravity of the stone	3.44
Specific gravity of maskelynite	2.65

The small amount of iron present would probably raise the specific gravity of the stone higher than 3.44, if not counteracted by a lighter mineral.

The metallic iron is bright and silvery when polished. The larger pieces are about 1.5 mm. in diameter, but the smallest are mere specks. They are dispersed amongst the other grains in a very irregular and fortuitous manner. Some of the finest fragments are in the chondrules.

Troilite is in about the same proportion as metallic iron. It has a dark bronzy lustre.

This meteoric stone, like others that have been described, indicates that it came from a source in which heat sufficient to cause fusion was a normal condition, that it was disturbed in the process of crystallization, or soon subsequent to it, by which innumerable fissures were made in the crystalline grains, and the separated fragments recompacted, and that after complete consolidation a second period of heat was experienced, a heat, however, which was applied to the external surface and was intense enough to momentarily fuse the minerals in contact with it, forming the dark glassy crust that now covers the mass. That this crust was once in a fused condition is indicated by the ridged, wavy contour of the surface, resembling a viscous substance congealed when in a greatly disturbed condition.

The chemical characters and the conclusion as to the mineralogical composition will be given in a later paper.

Paris, Dec. 31, 1895.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Geologic Atlas of the United States. By the U. S. Geological Survey: J. W. POWELL, Director; BAILEY WILLIS, Editor of geologic maps; S. J. KÜBEL, Chief engraver. (Washington, D. C., 1894 and 1895.) The first twenty parts, called folios, of the elaborate atlas which is designed to include maps and descriptions of our entire national domain, have been issued. In the "library edition" for general distribution and sale (at 25 cents each), the descriptive text of folio 1 is dated January, 1893, and its map sheets July, 1893, but the title page bears the date 1894. In folio 20 the dates are, for the text, April, 1895; and for the map sheets, July, 1895.

Seventeen of these folios cover, for each, an area bounded by a half degree of latitude and longitude on each side, and are on the scale of 1: 125,000, or slightly less than two miles to an inch, which is to be the scale for nearly all the atlas. The Livingston folio, in Montana, and the Lassen Peak folio, in California, are enclosed by sides measuring one degree, and are on the scale of 1:250,000; and the Anthracite-Crested Butte folio, in Colorado, comprises maps of two adjoining areas, each a quarter of a degree long and wide, on the scale of 1:62,500, or almost a mile to an inch.

The Pike's Peak folio, between 38° 30' and 39° latitude, and between 105° and 105° 30' longitude, has a length of 34.5 miles and a width of 27 miles, approximately, thus including 931.5 square miles. As the entire area of the United States (without Alaska) is about 3,025,000 square miles, it would require 3,250 folios, if all were on this uniform scale, with no allowance for the fractional folios on the boundaries, by which the number must be considerably increased. At an average rate of publication of thirty-five folios yearly, therefore, the atlas will require a hundred years for its completion. The beginning of this vast work is most admirably performed. The practical usefulness of these maps and descriptions, and their great value in advancing science, will undoubtedly secure, as they certainly deserve, the continued and generous support of Congress through the long time, whether fifty years or a century or more, which will be needed for thoroughly accurate and detailed topographic and geologic mapping of all the country.

In size the folios measure about 18 by 22 inches, and the map sheets nearly 14 by 18 inches, outside of which, on the margins, are the titles, legend, scale, etc. On the inside pages of the stiff paper covers of each folio, Director Powell gives an excellent explanation of the contour lines and other topographic delineations, and of the principles of geology, so fully as to enable any intelligent person to study the maps and sections understandingly, and to learn from them the form and relative altitudes of the land surface and the areal and structural relations of the rock formations.

Each folio has several pages of description, introduced by a general statement of the grand topographic and geologic features of the region to which it belongs, repeated nearly the same in other folios of that region. The special contour and the development of the geologic formations in the limited district of the folio are described in much detail; and the economic resources, especially for mining and quarrying, the varieties of soil, and their adaptation for agriculture, are very fully noted.

The first map sheet in each folio shows the topography, with contour lines, printed in brown, having vertical intervals of 100 feet, excepting the Livingston and Lassen Peak folios, in which the contours are 200 feet apart, and the Fredericksburg folio, lying wholly on the coastal plain of Virginia and Maryland, which has contours for each 50 feet. The drainage, as rivers and smaller streams, lakes, marshes, and the sea, are printed in blue; and "the works of man, called *culture*, as roads, railroads, boundaries, villages and cities," and all the nomenclature, are in black.

A second sheet adds to the preceding the color-printing by which the areal geology is displayed.

A third sheet, in every folio excepting the Fredericksburg, is a somewhat modified geologic map, giving special prominence to the economic geology, as formations bearing ores, coal, or building or ornamental stone, and the locations of mines and quarries.

A fourth sheet, in all excepting the Fredericksburg and Lassen Peak folios, is geologically colored but is crossed by narrow blank belts in which the sections of the rock structure are displayed, drawn on the same scale for both length and hight.

Finally in about half of the folios, a sheet is devoted to columnar sections, noting the stratigraphic order and the approximate thickness of each rock formation, with their geologic classification and lithologic characters, and the prevailing topographic condition of their areas.

Arranged in geographic order from east to west, and secondarily from north to south, the folios thus far printed and distributed are as follows:

Fredericksburg folio (13), in Virginia and Maryland, by W J McGee and N. H. Darton.

Harper's Ferry folio (10), in Virginia, West Virginia, and Maryland, by Arthur Keith.

Staunton folio (14), in Virginia and West Virginia, by N. H. Darton.

Estillville folio (12), in Virginia, Kentucky, and Tennessee, by Marius R. Campbell.

Knoxville folio (16), in Tennessee and North Carolina, by Arthur Keith.

Kingston folio (4), in Tennessee, by Charles Willard Hayes.

Cleveland folio (20), in Tennessee, also by C. W. Hayes.

Chattanooga folio (6), in Tennessee, by C. W. Hayes.

Sewanee folio (8), in Tennessee, by C. W. Hayes.

Ringgold folio (2), in Georgia and Tennessee, by C. W. Hayes.

Stevenson folio (19), in Alabama, Georgia, and Tennessee, by C. W. Hayes.

Livingston folio (1), in Montana, by Arnold Hague, Joseph P. Iddings, and Walter H. Weed.

Pike's Peak folio (7), in Colorado, by Whitman Cross; with a special map and description of the Cripple Creek mining district, by Whitman Cross and R. A. F. Penrose, Jr.

Anthracite-Crested Butte folio (9, price 50 cents), in Colorado, having two sets of map sheets and descriptions, by Samuel Franklin Emmons and George H. Eldridge.

Lassen Peak folio (15), in California, with illustrations of recent volcanic activity (about 200 years, and again somewhat more than 50 years ago), by J. S. Diller.

Smartsville folio (18), in California, by G. F. Becker, Waldemar Lindgren, and H. W. Turner.

Marysville folio (17), in California, also by Messrs. Becker, Lindgren, and Turner.

Placerville folio (3), in California, by Messrs. Becker, Lindgren, and Turner.

Sacramento folio (5), in California, by Messrs. Becker and Lindgren.

Jackson folio (11), in California, by Messrs. Becker and Turner.

One folio belongs to the Atlantic coastal plain; ten folios map and describe districts of the Appalachian mountain belt; three folios belong to the Rocky mountains; and the remaining six to the Sierra Nevada region and the contiguous Sacramento valley. W. U.

Ueber Archæische Ergussgesteine aus Småland. By OTTO NORDENSKJÖLD. (Bull. Geol. Instit. Upsala, no. 2, vol. I, 1893.) The term hälleflinta (eurite and granulite) has been used indiscriminately to cover a great variety of compact microcrystalline, more or less banded rocks. Recent microscopic investigation of these pre-Cambrian microcrystallines, in the light of the results of the study of post-Cambrian volcanics, is rapidly revealing the diversity of rock-types found among them. Some of the so called hälleflintas proved to be indurated sediments, or tuffs, and many of them are ancient effusives or other igneous rocks. This service of identification and classification Dr. Nordenskjöld has accomplished for the Swedish hälleflintas, which prove to include both rocks of sedimentary and of igneous origin.

Hälleflintas play an important role among the geological formations of Sweden, where they constitute a considerable portion of the Archean rocks, and where they carry the metalliferous ores. In Småland, a district in southeast Sweden, embracing the provinces of Jönkölping, Kronoberg and Kalmar, they occur in four more or less parallel bands, having a length of from 60 to 100 kilometres and a breadth of from 10 to 15 kilometres. The most northerly of these bands, that of the region of Sjögelö, has been the subject of detailed study on the part of the author.

While exhibiting some phases of the crystalline schists, with which they have always been classed, Dr. Nordenskjöld finds that the hälleflintas are unmistakably united by transition phases with massive granular rocks. The structures and other features described by the author permit of no doubt of the igneous origin of the hälleflinta and hälleflinta-gneiss of Sjögelö.

They separate into the following groups:

Hypidiomorphic granular rocks:
  Granite, aplite, gabbro.
Porphyritic rocks:
  Occurring as massive rocks,
    Granite porphyry and microgranite.
    Granophyre and an augite-bearing-porphyritic granophyre.
  Occurring as dyke-rocks,
    Granite-porphyry, diorite-porphyrite, uralite-diabase-porphyrite.
Effusive rocks.
  Eorhyolite, eodacite, pyroclastics, diorite, augite-porphyrite.

The granites are fine grain, aplitic and frequently show a gneiss-like alternation of light and dark bands, which the author is inclined to consider an original fluidal structure. The chief interest of the granites lies in the fact that they merge into hälleflintas through this gneissoid banding, or fluidal structure, and an increasingly finer crystallization. The gabbros, also, stand in the same close relation to the basic members of the hälleflinta formation.

The porphyritic rocks constitute another transition between the granites and the hälleflinta proper. Granite porphyries, formerly denominated hälleflinta or hälleflinta-gneiss, possess a micrograniitic groundmass in which are imbedded phenocrysts of orthoclase, plagioclase, and biotite. The micrograniites form the chief mass of the hälleflinta and are both porphyritic and non-porphyritic. They are characterized by a finely crystalline groundmass closely related in structures to that of the eorhyolites. Sericite is often abundantly developed. There are typical granophyres which, like the quartz-porphyries of the South mountain, pass into sericite schists.

The porphyritic dyke-rocks occur as composite dykes some 40 meters wide and consist of an acid porphyritic centre with a selvage of diabase-porphyrite. Orthoclase is essential to all of the acid types. Quartz is often missing without the composition of the rock becoming more basic. Hornblende is rare. The groundmass is a finely crystalline mosaic of quartz, orthoclase, plagioclase and microcline. The effect of pressure is seen in cracks and undulatory extinction. For petrographical descriptions of the basic dyke-rocks (diorite-porphyrite and uralite-diabase-porphyrite) the author refers to the papers of Eichstädt and Holst.

The ancient acid effusives occur in the greatest perfection in the Sjögelö district. They constitute almost half of the entire district, and while they closely resemble the English, Belgian and American ancient rhyolites, nowhere else have they shown a transition into granites. These "eorhyolites" are characterized in the hand specimen by a dense grayish black groundmass, which may or may not be porphyritic. When phenocrysts are present, they are exceedingly numerous and especially conspicuous upon the weathered surface. They are plagioclase, orthoclase, biotite or quartz. The accessory constituents are magnetite, ilmenite, titanite, apatite and zircon. The secondary constituents are calcite, epidote, chlorite, fluospar, rutile and prehnite.

The interesting feature of the rock is the groundmass, which is exceedingly fine grained and exhibits microscopically a considerable diverity of structure: (1) It may be a microcrystalline granular aggregate of quartz and feldspar, with a preponderance of the quartz. (2) It may exhibit a structure to which the author gives no name, but which seems closely similar to the micropoikilitic structure so common in ancient rhyolites and quartz-porphyries. (3) It may be microfelsitic. (4) It may be composed largely of brightly polarizing blades of a light greenish to colorless mica, probably sericite. (5) There occurs a more coarsely granular groundmass, in which muscovite and biotite, which may be primary, are abundantly present.

Among the secondary constituents, epidote is the most abundant and the most interesting in its varieties. Two species are present, pistazite and withamite. The latter species closely resembles piedmontite in its colors. The author calls it withamite only because of the scanty amount of manganese shown to be present by the chemical analyses of the rock. Similarly the occurrence of epidote and of piedmontite in marked abundance is a feature of the South Mountain aporhyolites.

The eodacites show the same structures as the eorhyolites, but are characterized mineralogically by the presence of hornblende, while quartz and orthoclase become accessory constituents.

With the pyroclastics, the author places the eutaxites (Spaltungsbreccia) which are widespread and show many of the interesting structures peculiar to surface lavas. The spherulitic (rarely axiolitic), the fluidal and the cryptopegmatitic structures are conspicuously present. Eovolcanics, for the most part eutaxites, are found in the region between lakes Kolsjön and Flen and the village of Kulla, exhibiting perlitic parting and spherulitic and lithophysal structures in great perfection.

The agglomerates (genuine volcanic breccias) are composed of fragments which are not "schlierenartig," nor do they show a fluidal arrangement, but still they are not essentially unlike the main mass of the rock. The rhyolitic structure of Rutley and De La Vallée Poussin, the "Aschenstructur" of Mügge, is characteristic of a specimen from Faggemåla, placed provisionally in this group of agglomerates. This structure Mügge,* for excellent reasons so far as the "Lenneporphyre" is concerned, considers characteristic of tuffs. Whether it is always to be so interpreted only continued investigation can show. In the case of the Småland volcanics, and it is also true of the South Mountain volcanics, the absence of stratification and the transition into eutaxites argues against this interpretation. In this region (Sjögelö) there also occur some remarkable rocks, which have been characterized by Holst as conglomeratic hälleflintas, but which prove to be made up of spherulites (Kugelfels). Both the description and photograph of the spherulites vividly recall the spherulites of the Raccoon Creek aporhyolites. Dr. Nordenskjöld observes that not infrequently, especially upon the weath-

*Untersuchungen über die "Lenneporphyre" in Westfalen und den angrenzenden Gebieten; Neues Jahrbuch für Min. Geol. und Palæ., B. B. VIII, 1893, pp. 648, 649, 713.

ered surface, the centres of the spherulites are vesicular or filled sometimes with calcite. This was not infrequently the case with the South Mountain aporhyolites, and has led the reviewer to conclude that spherolitic centres are points of easy solution and redeposition.

The chemical composition as well as the structures ally these ancient effusives to their modern equivalents, while the preponderance of soda over potash relate them to the keratophyres and dacites. That a considerable manganese percentage is always present is noticeable.

Basic Volcanics: The greenstones or dioritic rocks found on the west side of lake Kalsjön possess a diabase-porphyritic structure, which is nearly obliterated by alteration. The chief constituents are secondary epidote and chlorite. The augite-porphyrites still show a typical structure. The original constituents, however, are almost completely replaced by epidote, chlorite and biotite.

The Småland hälleflintas are the oldest known of the Swedish volcanic rocks. Sederholm separates the pre-Cambrian formations of Sweden into three divisions: The Katarchæan complex, the Bottnian system and the Karelian system (Algonkian.) The hälleflintas of Småland are placed in the Katarchæan complex, while the hälleflintas of Elfdalen are Karelian, and Sederholm's uralite-porphyrites are Bottnian.

In dealing with the question of nomenclature the author reaches the following conclusions: These hälleflintas are not the felsophyres or vitrophyres of Rosenbusch, as they contain neither glass nor true microfelsite. They are identical with the ancient rhyolites of Allport, Rutleo, De La Vallée Poussin and Williams. They are, however, in every case so different from typical rhyolites that a cursory examination serves to separate them. These constant differences should be recognized in a name. Felsite has been used by English petrographers and by Stolpe among Swedish petrographers for rocks of this class. This term is to be discarded however on the ground that it already has a definite meaning, viz., a non-porphyritic quartz-porphyry. In view of these facts the author proposes the name *eorhyolite* for the ancient devitrified rhyolites, and suggests that in an analagous way the terms *eoandesite*, *eobasalt*, etc., should be formed: also that palæo- (or meso-) and neo- should be prefixed to the effusives of those respective ages.

The author recognizes the fact that there is no definite petrographical distinction between pre-Tertiary and post-Tertiary volcanics, but a difference in habit is well established. This difference in habit is shown for instance in the frequent occurrence of an adiognostic or cryptocrystalline groundmass containing sericite and porphyritic constituents, with indistinctly idiomorphic boundaries (through secondary growths?), in the abundance of secondary constituents and in the appearance of the spherulites, etc. As to the cause of these differences between ancient and recent volcanics there can be but two views: (1) An original difference in the conditions of eruption; the cause of this original difference is partially unknown, and is partially to be explained in connection with the cooling of the earth's crust. This idea justifies the establishment of a class of rocks older than and unlike the palæovolcanics (eovolcanics). (2) According to the second view the differences of habit just mentioned are due to alterations secondary to the consolidation of the rock. This view seems the more probable, because palæovolcanic rocks which have undergone dynamic metamorphism resemble the eovolcanics, while those that have not undergone such metamorphism are inseparable from the neovolcanics. Even though this view were true, the author thinks it is fitting to separate these rocks by such a name as eorhyolite until the correctness of the view and the exact character of the metamorphism is established. He recognizes the difficulty at once met with in consistently carrying out this nomenclature, viz., the impossibility of separating the younger quartz-porphyries, which have been altered by dynamic metamorphism, from the eorhyolites. The author states that the most important change which these rocks have undergone is devitrification (Entglasung) on a large scale. This was the case with the corresponding rocks of the South mountain, and was the occasion for the proposal of the name aporhyolite.*

If devitrification were a function of time only and demanded for its consummation such long periods of time as to confine its occurrence to the eorhyolites, i. e., to pre-palæovolcanics, that name could fitly cover all rhyolites showing this phase of alteration. The reviewer's idea is that glassy lava is in a condition of unstable equilibrium; that glass always tends to become stony, that while this process may take place slowly during considerable periods of time, it may also take place with comparative rapidity if the glass be subjected to heat or pressure; in short, that devitrification is a function of both time and conditions of heat and pressure, and that the time called for varies with the composition of the glass, and may not be nearly so long as is implied by confining devitrification to eorhyolites.

The tendency of glass "to degenerate" is a common experience in chemical laboratories. It has been observed in the chemical laboratory of Bryn Mawr College that glass tubing which has been kept on hand more than three years, will, upon slight heating (not to fusion) instantly become opaque and rough. The microscope shows the roughness and opacity to be due to a fine network of cracks, within and along the edges of which incipient crystallization has taken place. It is becoming a recognized fact among chemists that certain chemical combinations, which were formerly supposed to take place only at very high temperatures, will also take place at much lower temperatures, but very slowly. The converse is equally true. Fresh glass tubing remains perfectly clear under the action of heat, but during three years it had plainly passed into a state of unstable equilibrium. Under the action of heat it rapidly passed into a more stable form, a condition which it would not have reached for a long time without that aid. That this period of time is not of indefinite duration is shown by the well known devitrification of window glass, nor is devitrification unknown in post-Tertiary glassy lavas. The rhyolitic lavas of the Rosita hills, Colorado,* show devitrification in residual areas around the spherulites. In this

*The Journal of Geology, vol. I, no. 8, Nov.-Dec., 1893, p. 828.

case there has been no dynamic action. The only agencies at work since the close of eruptive activity have been those of decomposition and erosion.

If we grant that it is conceivable that palæorhyolites and neorhyoiltes may acquire the habit of eorhyolites, due to the same processes of devitrification, and associated changes, is it not well to have a common term for all rhyolites of that habit, leaving their age to be indicated by an additional prefix, or by an adjective, as in the case of the deep-seated rocks? F. B.

New and Interesting Species of Palæozoic Fossils. By S. A. MILLER and WM. F. E. GURLEY. (Bulletin No. 7, Illinois State Museum of Natural History; 89 pp., 5 pls.; Springfield, Ill., December 5, 1895.) The present *Bulletin* introduces among Paleozoic Crinoidea alone, no less than four new generic and 56 new specific names, which are applied to specimens, not in the State Museum, but in private collections, especially those of the authors. When we see the names of these two gentlemen on a title page we know what to expect. Detailed criticism becomes a work of superogation. The character of the work and the competence of these "distinguished and laborious collectors," as they presumably would wish to be described, may, however, be gathered from an examination of some statements on the first page that opened to my hand.

On pp. 80, 81 the writers describe "*Pisocrinus milligani* n. sp." found by Mrs. Milligan, in the Niagara group of Decatur Co., Tenn. This species is said to resemble *Pisocrinus gorbyi*, which, however, is longer in proportion to the diameter. The cup "expands in the radial regions, giving to the upper part a pentalobate aspect." A specimen that "does not show the sutures in the calyx" is figured, and it is stated that "Figs. 21, 22 and 23, on Plate VI of the 17th Report of the Geological Survey of Indiana belong to this species."

Permit me now to quote a paragraph from "The Crinoidea of Gotland. Part I." (*Kgl. Svenska Vet.-Akad. Handlingar.* Bd. XXV, No. 2; 1893.) On p. 27 it is written, "The *nomen nudum et barbaricum* '*Pisocrinus pentalobus*,' W. and Sp.", which occurs in a note by Mr. C. S. Beachler as indicating a species found in Niagara beds at St. Paul, Decatur Co., probably refers to *P. Gorbyi*. (Amer. Geol., March 1891, p. 179. The more correct *quinquelobus* would admirably suit the new Tennessee form.) It is, however, a little uncertain whether *P. gorbyi* does not include two species. I have, for some years, been acquainted with a species from the Niagara group of W. Tennessee, of which the following is a diagnosis:—Dorsal cup low; pentagonal as seen from ventral surface, the angles of the pentagon being radial in position: the radial facets are very narrow, the radial processes correspondingly broad, forming the concave sides of the pentagon: basals hidden in the concavity for the stem. Now, this seems to agree with specimens collected by Prof. Gorby in W. Tennessee and figured by

* Whitman Cross: Geology of the Rosita hills, Custer Co., Colo. Proc. Col. Sci. Soc., 1890, p. 279.

Mr. Miller, (*op. cit.*, Pl. VI, Figs. 21, 22, 23). The type specimens of *P. Gorbyi*, however, which come from Indiana, have, as Mr. Miller points out, a more elongate and conical cup; the basals also are far more visible on a side view."

It is perfectly clear that the "*Pisocrinus milligani*" of Messrs. Miller and Gurley is identical with the form for which I proposed the name *Pisocrinus quinquelobus*. It is contrary to my principles to describe new species from a country that numbers eminent authorities on the group among its own scientific men; in the present instance, I did so merely because a name had already got into circulation which I was anxious to identify in my revision of the whole genus. However, I left the specimens collected by Prof. Gorby as co-types of the species, the other co-types being in the British Museum and registered E 5493. The point is that Mr. Miller had a copy of my paper sent to him immediately on its publication, and that he received it and studied it, as is shown by his own correspondence with me. Few would wish to deprive Mr. Miller of the honor of his numerous species; but this open-eyed robbery is too un—, well shall we say too unscientific,—a proceeding to pass without protest.

There is one small point in which my description is so unfortunate as to differ from that of Messrs. Miller and Gurley. They say, "The five basal plates" are "seen in a side view even plainer than they can be in *P. gorbyi*." I said in "the type-specimens of *P. Gorbyi* which come from Indiana, the basals are far more visible in a side view." My statement was based on the figures in the 17th Report of the Geological Survey of Indiana as well as on specimens in the British Museum, and I cannot help thinking that some slip must have crept into the description by Messrs. Miller and Gurley.

In "The Crinoidea of Gotland" (*tom. cit.*, p. 24) the remarkable views of Mr. Miller as to the morphology of *Pisocrinus* have already been discussed at such length as they seemed to deserve, and I still cannot help doubting that "each arm-blade consists of a single plate." Perhaps in the specimens from Decatur county weathering has somewhat obscured the true appearances.

But even those acquainted with Mr. Miller's original views on echinoderm morphology can hardly have been prepared for such a sentence as this: "It must be apparent to any one having been a student of the Echinodermata that *Pisocrinus* is not more nearly related to the order *Palæocrinoidea* than it is to the *Blastoidea*. It has neither the arms nor the vault of a crinoid, besides being anomalous, in the arrangement of the plates of the calyx." In the work already referred to it is shown that *Pisocrinus* is not anomalous, or at all events that its anomalies are shared to a greater or less extent by *Triacrinus*, *Calycanthocrinus*, *Haplocrinus*, *Heterocrinus*, *Ectenocrinus*, *Ohiocrinus*, *Anomalocrinus*, *Herpetocrinus*, *Castocrinus*, *Euchirocrinus*, *Calceocrinus*, *Halysiocrinus*, *Mycocrinus*, and *Catillocrinus*. This interpretation of the structure of *Pisocrinus* has received the approval of many eminent authorities on the Crinoidea, among whom I will only mention Dr. O.

Jaekel of the Berlin Museum, in his "Beiträge zur Kenntniss der Palæozoischen Crinoiden Deutschlands" (*Palæont. Abhandl.*, VII, Heft. 1, p. 44; Jena, 1895.)

The remark of Messrs. Miller and Gurley is therefore much as though they were to say: "It must be apparent to any one having been a student of the Vertebrata that a whale is not more nearly related to the Mammalia than it is to the Reptilia." Such a student would indeed be one of the "have-beens."

This review has dealt with only a page and a quarter of the *Bulletin;* but that may serve as a fair sample of all Mr. S. A. Miller's writings on Palæozoic crinoids, whether by himself or in collaboration with some other collector or state-official. Now the publication of some sixty "new species" of this character per annum is a serious matter to various classes of people: first, to zoologists and paleontologists generally, who are led astray by a publication that they fondly suppose to be issued with some authority: secondly, to bibliographers, who have the no small labour of recording these lists of names: thirdly, to specialists, who have the wearisome and sisyphean task of revising these ill-ordered masses year by year; fourthly, to American men of science, who run the risk of being confused by the outside public with the Millers and Gurleys of their country; fifthly, to Governor John P. Altgeld, Secretary William H. Hinrichsen, Superintendent S. M. Inglis, and all the people of Illinois, the reputation of whose State Museum is being rapidly ruined and whose money is being squandered with little other result than the enrichment of the private collections of state-paid officials.

I regret to see a man of Mr. S. A. Miller's undoubted ability led away by this lust for coining new names. Mr. Miller has done good work for science, and his catalogue of American fossils has made his name known and his labours valued in all civilised countries. If nothing else will serve, let us try the effect of a strong personal appeal to Mr. Miller, to cease burying his talent in, not a napkin, but a heap of waste-paper or worse, and to devote it once more to his Bibliography, which will bring him in far greater returns. F. A. BATHER.

Geological Survey of New Jersey, Annual Report for 1894. JOHN C. SMOCK, State Geologist. (Pages 304, with a large folded map of the surface formations in the valley of the Passaic, and eleven plates. Trenton, N. J., 1895.) The first half of this volume is a report of progress in the exploration and study of the surface geology, by Prof. ROLLIN D. SALISBURY, assisted by Messrs. Kümmel, Peet, and Knapp, with the large map before mentioned and four plates. In the next 77 pages LEWIS WOOLMAN treats of artesian wells in the Miocene and Cretaceous strata of the southern part of the State, with six plates; and the remainder of the volume is chiefly occupied by reports on forestry, for the northern part by C. C. VERMEULE, and for southern New Jersey by JOHN GIFFORD, with a map showing the percentage of areas in forest.

The glacial and stratified drift, glacial striæ, changes of drainage during the Ice age, and postglacial changes, in northern and central

New Jersey are described in much detail. The Beacon Hill, Pensauken, and Jamesburg formations, previously noticed in the AM. GEOLOGIST for last March (vol. xv, pp. 203, 204), are again carefully considered in three successive sections of Prof. Salisbury's report.

The Beacon Hill sand and gravel, lying stratigraphically the lowest in this series, are correlated with the formations farther south which Prof. W. B. Clark has classed as Miocene.

Next in ascending order, the Pensauken sand and gravel formation has received much study, and Prof. Salisbury writes: "There can no longer be any doubt that the Pensauken is the equivalent of the Lafayette formation of the south. This conclusion was reached tentatively more than a year since. Recently, Mr. McGee was kind enough to spend several days in the study of the formation at various points, from Millville to Kingston, and at the close of his study expressed his conviction, without qualification or reservation, that the Pensauksen and the Lafayette are one. If the ice which co-operated with water in the deposition of the Pensauken was berg ice—emanating from glaciers—it is believed that it belonged to a glacial epoch antedating any which has heretofore been recognized in North America."

The next succeeding Jamesburg formation, which consists of a thin mantle of gravel, sand, and loam, frequently inclosing boulders, is confidently correlated with "the Columbia of the south as defined by McGee. Not only this, but it is also clear that there have been referred to the Jamesburg, deposits which correspond in a general way with the 'high-level' and 'low-level' Columbia. The relation of these two subdivisions to each other has not yet been fixed with certainty, but will receive attention in the immediate future." At the close of the long description of this formation, it is stated that "the exact age of the Jamesburg, in terms of the glacial period, is one of the questions which awaits solution, so far as New Jersey is concerned, though it is not believed to be insoluble." It is succeeded by the Trenton gravel and sand, which belong with the chief moraine-forming stage of the ice-sheet.

In the very interesting and detailed report on artesian wells, the section of the well 1,244 feet deep at Wildwood, on Holly beach, about seven miles north of Cape May, is shown to comprise, first, Recent and Pleistocene beds, 291 feet, in which, from 78 to 179 feet, many intermingled freshwater and marine diatoms were found, the freshwater forms being far predominant; next, Miocene beds, 810 feet, including 423 feet, from 370 to 793 feet below the surface, throughout which marine diatoms occur; and glauconitic sand, 140 feet, referred provisionally to the Eocene Pamunkey formation.

The descriptions of the forests of New Jersey, and of measures now being taken for their preservation, are excellent, especially for the southern part, where much damage has been done by forest fires. W. U.

Geological Biology, An Introduction to the Geological History of Organisms. By HENRY SHALER WILLIAMS. (395 pp., 120 cuts. Henry Holt & Co.) This work occupies a somewhat unique place in natural history studies. It treats especially of the morphology of organisms, but almost entirely of extinct forms. Hence it is of particular interest to the paleontologist. It is also of service to the evolutionist, since extinct forms are of most service in demonstrating the laws of phylogeny.

The work may be divided into two parts,—the first treating particularly of the geological, and the second of the biological phases of the subject. The opening chapter deals with the scope and importance of the history of organisms. Chapter II, which treats of the making of the geological time scale, is of much interest to both geologist and paleontologist. This subject is treated historically, and the development of our present time scale is discussed at some length. The following chapter treats of the divisions of the time scale and of their time values. The several geological revolutions are briefly stated and their relations to the major divisions of the time scale pointed out. Then follows a discussion of the comparative lengths of the several divisions of the time scale and the methods of computing these. Chapter IV treats of the stratified rocks, and chapter V of fossils and their geological range. The next two chapters relate to the geographical distribution of organisms and of their relation and adjustment to environment.

With chapter VIII begin the strictly biological phases of the work. The nature of species is first discussed. Ideas of various naturalists as to what constitutes a species are stated, and the nature of the mutable and immutable schools discussed. "What is an organism?" is considered in chapter X, which also contains a brief statement of the principles of embryology. In the chapter on the origin of species the views of Darwin and Cope are stated as illustrating the nature of the problem and also the different views held by naturalists as to the cause of the phenomena of evolution. The decision is reached by our author that the origin of species is still an open question. The age of the various characters of organisms is also discussed in this chapter, and it is shown that this varies greatly. Thus in the brachiopod *Spirifera logani* Hall the class characters extend from the beginning of the Cambrian to the present time, while the specific characters extend over a portion of Eo-Carboniferous time only.

Chapter XI opens with a discussion of the nomenclature used in classification. The ideas of Aristotle, Linné, Cuvier and others are stated, and it is shown that in tracing out the history of organisms species and genera are of most service. This chapter contains also a brief statement as to the methods by which the history of organisms may be studied. These methods are two: (1) the zoölogical method depending largely upon embryology, and (2) the paleontological method depending upon fossils. While these two plans are diverse, it is claimed that their results in the main agree. This chapter further contains an instructive discussion as to the differentiation among organisms that existed in Cambrian time. This differentiation is shown to have been very great and was "present at the beginning of the records." With the exception of the vertebrates all the grand types of organisms lived in these early Cambrian seas, but "So far as these grander differences of organization are concerned the millions of years of geological time throw no light upon the way by which they came about."

The remaining chapters of the book are devoted to the evolution of organisms. The first group of animals taken illustrating this law is the Brachiopoda. First, the time range of the several groups of these organisms is stated. In this manner the geological range of the class, ordinal, and generic characters is demonstrated. Next a species is studied in detail and the time of appearance of its class, ordinal, and subordinal characters pointed out. A chapter is devoted to the life history of genera, as shown in the spire-bearing brachiopods. Other chapters are given to a study of cephalopods and ammonoids as illustrating laws of phylogeny. The conclusion is reached that the more important characters of organisms, such as distinguish classes, orders and genera, attain a comparatively rapid development; while the less important characters, such as distinguish species, develop more slowly. J. A. B.

Canadian Fossil Insects. By S. H. Scudder. (Geol. Sur. Canada, Contributions to Canadian Palæontology, vol. 2, pt. 1, 66 pp., 5 pls., 1895.) Mr. Scudder describes the Tertiary Hemiptera of British Columbia found by Dr. G. M. Dawson, at three places,—Quesnel on the Fraser river, the north fork of the Similkameen, and Nine-Mile creek, another branch of the same. Nineteen species are described, almost all being homopterous. Every specimen, moreover, is assigned to a different species and only in one case are two species referred to the same genus. The insects are also of large size for the most part, some of the Fulgoridæ and Cercopidæ measuring four fifths of an inch in length. The illustrations are made from drawings in India ink by Mrs. Katherine P. Ramsay.

The second part of this work treats of the Coleoptera hitherto found fossil in Canada, which have been obtained from seven distinct localities in post-Pliocene, lower Tertiary and Cretaceous strata. The last has yielded but a single species,—a curculionid from Manitoba.

The myriapods and arachnids, though not strictly insects, are included in the third part. These, which were first brought to light by Sir. Wm. Dawson thirty years ago, have been chiefly obtained from the stumps of sigillarian trees in Nova Scotia, as described in "Acadian Geology." As an illustration of the care and minuteness with which Sir Wm. Dawson has carried on his investigation Mr. Scudder says, "In his examination of the reptilian coprolites of these sigillarian stumps [he] has extracted the fragment of a facetted eye about three-quarters of a millimetre square and containing from one to two hundred perfectly regular hexagonal facets." The illustrations are by Mrs. Ramsay and Mr. Blake. E. W. C.

The Quarries in the Lava Beds at Meriden, Conn. By W. M. Davis. (Amer. Jour, Sci., 4, vol. 1, pp. 1-13, Jan., 1896.) In this paper Prof. Davis makes another contribution to the geology of the Triassic trap ridges of the Connecticut valley. The special point made is the occurrence of earlier and later flows of lava as evidenced by the superposition of the dense lower material of a later sheet on the light vesicular upper part of an earlier one. E. W. C.

RECENT PUBLICATIONS.

I. Government and State Reports.

Geol. Sur. of N. J., Ann. Rept. for 1894. Surface geology—report of progress, R. D. Salisbury; Report on artesian wells in southern New Jersey, Lewis Woolman.

Geol. Sur. of Canada, Contr. to Can. Palæon., vol. 2, pt. 1, 1895. Canadian Fossil Insects (Myriapods and Arachnids), S. H. Scudder: The Tertiary Hemiptera of British Columbia: The Coleoptera hitherto found fossil in Canada: Notes on myriapods and arachnids found in sigillarian stumps in the Nova Scotia coal field.

Instituto Geologico de México Boletin 2. Las rocas eruptivas de suroeste de la Cuenca de Mexico, Ezequiel Ordoñez. 46 pp., 1895.

U. S. Geol. Survey, Bull. 123. Contributions to the Cretaceous paleontology of the Pacific coast: The fauna of the Knoxville beds, T. W. Stanton. 132 pp., 20 pls., 1895.

II. Proceedings of Scientific Societies.

Bull. Am. Geog. Soc., vol. 27, no. 4, 1895. The development of the geologic atlas of the United States, Bailey Willis; Topography and scenery of northern India, H. M. Wilson.

Proc. Alabama Indust. & Sci. Soc., vol. 5, 1895. Alabama barite or heavy spar, Henry McCalley; Alabama's resources for the manufacture of Portland cement, E. A. Smith.

Jour. Elisha Mitchell Sci. Soc., vol. 12, pt. 1, 1895. Notes on the underground supplies of potable waters in the south Atlantic Piedmont plateau, J. A. Holmes.

III. Papers in Scientific Journals.

Ottawa Naturalist, Jan. Erythrite, stilpnomelane var. chalcodite, crystallized monazite and pleochroic apatite from some Canadian localities, W. F. Ferrier: Notes on some fossils from the Trenton of Highgate Springs, Vermont, near the Canadian boundary line, H. M. Ami.

Science, Jan. 10. The Geological Society of America, J. F. Kemp; Current notes on physiography, W. M. Davis.

Science, Jan. 17. A gigantic orthoceratite from the American Carboniferous, C. R. Keyes.

Science, Jan. 24. Current notes on physiography, W. M. Davis.

Science, Feb. 7. Memorial address on J. D. Dana, J. W. Powell; Current notes on physiography, W. M. Davis.

Amer. Naturalist, Feb. Some localities for Laramie mammals and horned dinosaurs, J. B. Hatcher.

Amer. Jour. Sci., Feb. Notes on sperrylite, T. L. Walker; Glaciation of Pocono Knob and Mounts Ararat and Sugar Loaf, Pennsylvania, H. B. Kümmel; Fayalite from Rockport, Mass., and on the optical properties of the chrysolite-fayalite group and of monticellite, S. L. Penfield and E. H. Forbes.

Jour. of Geology, Jan.-Feb. Review of the geological literature of the South African Republic, S. F. Emmons; Igneous intrusions in the neighborhood of the Black hills of Dakota, I. C. Russell; The geology of New Hampshire, C. H. Hitchcock; North American graptolites, R. R. Gurley.

Kansas Univ. Quarterly, Jan. The sands of the Kansas River valley, M. Z. Kirk; "Horsebacks" in the Kansas Coal Measures, W. R. Crane; A preliminary report on the glaciated area of Kansas, E. G. Swem; A geological section at Providence, Mo., Alban Stewart.

IV. Excerpts and Individual Publications.

Concretions of chalcedony and opal in obsidian and rhyolite in Colorado, H. B. Patton. 6 pp., 2 pls.; read before the Colo. Sci. Soc., Nov. 4, 1895.

Peculiar geological formations at the head waters of the Rio Grande, Colo., H. B. Patton. 2 pp., 2 pls.; read before the Colo. Sci. Soc., Nov. 4, 1895.

The production of aluminum in 1894, R. L. Packard. 16th Ann. Rept. U. S. Geol. Sur., pt. 3, pp. 539-546, 1895.

Bauxite, C. W. Hayes. Ibid., pp. 547-597, pls. 20-23, 1895.

The Tennessee phosphates, C. W. Hayes. Ibid., pt. 4, pp. 610-630, pl. 5, 1895.

Terminology proposed for description of the shell in Pelecypoda (Abstract), Alpheus Hyatt. Proc. A. A. A. S., vol. 44, pp. 145-148, 1895.

Notes and recollections concerning the mineral resources of northern Georgia and western North Carolina, W. P. Blake. Trans. Am. Inst. Min. Eng., Atlanta meeting, 15 pp., 1895.

Lake Passaic, an extinct glacial lake, H. B. Kümmel. Thesis for degree of Ph. D., Univ. of Chicago; 89 pp., 1 map, 1895.

A summary of progress in petrography in 1895, W. S. Bayley. From monthly notes in Amer. Naturalist; Waterville, Me., 1896.

Notes on some of the Cretaceous fossils collected during captain Palliser's explorations in British North America in 1857-'60, J. F. Whiteaves. Trans. Roy. Soc. Canada, 2d ser., vol. 1, sec. 4, pp. 101-117, pl. 1, 1895.

On some fossils from the Nanaimo group of the Vancouver Cretaceous, J. F. Whiteaves. Ibid., pp. 119-133, pls. 2-3, 1895.

Notes on the areal geology of Glacier bay, Alaska, H. P. Cushing. Trans. N. Y. Acad. Sci., vol. 15, pp. 24-34, pl. 1, 1895.

PERSONAL AND SCIENTIFIC NEWS.

Joseph Prestwich, professor of geology in the University of Oxford, has been knighted by Queen Victoria.

Prof. Harry Landes has been appointed professor of mineralogy and geology in the Washington State University at Seattle.

PROF. I. C. WHITE, of Morgantown, W. Va., was absent from home during the month of February on a cruise through the West Indies, going as far south as Caracas, Venezuela.

A BIOGRAPHICAL SKETCH OF JOSEF V. SZABO, the noted Hungarian geologist, who died April 10th, 1894, is given by Dr. A. Koch in Földtani Közlöny (Journal of the Hungarian Geological Society), vol. 25, Sept.-Oct., 1895. A portrait and bibliography accompany the sketch. Prof. Szabo's flame tests for the determination of the feldspars are well known.

THE KANSAS UNIVERSITY DEPARTMENT OF PHYSICAL GEOLOGY AND MINERALOGY has now passing through the press volume I of the reports of the University Geological Survey of Kansas, and hopes that it will be ready for distribution about the first of April. It will contain about 100 pages of text with many figures and plates, and is devoted almost exclusively to the stratigraphy of the Carboniferous area of Kansas.

MR. HUGH MILLER, F. R. S. E., F. G. S., son of Hugh Miller, author of "The Old Red Sandstone," died on Jan. 8th, 1896. He joined the Geological Survey of Great Britain in 1894 and was first employed in Northumberland and was later transferred to Scotland where he surveyed some of the ground in Cromarty made classic by his father's researches. He was a member and one of the vice-presidents of the Edinburgh Geological Society.

PROF. SOLLAS, F. R. S., will leave in March for Sydney, to take charge of an expedition that is being despatched to make deep borings in a coral atoll. The scheme, which is supported by a strong scientific committee, has been financed by the Royal Society to the extent of £800; and the Government are placing a gunboat at the disposal of the party, to convey them from Sydney to Funifuti, in the Central Pacific, which has been selected as the scene of operations. (*Nature.*)

MR. ROBERT HAY, one of the original fellows of the Geological Society of America and formerly one of the editors of the AMERICAN GEOLOGIST, died at his home in Junction City, Kansas, Dec. 14, 1895. For some time before his death he had been connected with the U. S. Department of Agriculture. Mr. Hay was the author of a number of papers on the geology of Kansas and of late years has been intimately connected with the investigation of the artesian wells in the southwest.

ALFRED L. KENNEDY, a metallurgist and geologist, was burned to death during a fire which occurred in his rooms, in Philadelphia, Pa., on January 30th. He was nearly 80 years old. He was a graduate of the University of Pennsylvania, and in 1853 established the Polytechnic College of Philadelphia and was its president until the college went out of existence a year ago. Dr. Kennedy was also the founder, vice-president and geologist of the State Agricultural Society. (*Eng. & Mining Jour.*)

DR. CHARLES WACHSMUTH, THE EMINENT AUTHORITY ON CRINOIDS, died at his home in Burlington, Iowa, on February 7th. In another place in the present issue of this journal will be found a sketch of the life and work of Dr. Wachsmuth, accompanied by a portrait and bibliography. The monograph on the camerate crinoids by Wachsmuth and Springer, now in press will be ready for distribution in a short time. Correspondence connected with the works of these authors may be addressed to Mr. Frank Springer, East Las Vegas, New Mexico.

NEW YORK ACADEMY OF SCIENCES.

At the meeting of the Geological Section, held on February 17th, 1896, the following papers were presented:

The first paper was read by Mr. L. McI. Luquer, entitled "Notes on recent Accessions of Interesting Minerals," with exhibitions of specimens. Mr. Luquer described in detail the minerals that he had recently discovered at the feldspar quarries in the northeastern part of Westchester county. They include uraninite, autunite, uranophane, washingtonite and the common minerals of pegmatite veins. He showed that the veins occurred in close association with an area of augen-gneiss, regarded as intrusive and now being studied by himself and Mr. Heinrich Ries.

The second paper was by J. F. Kemp, entitled "The Cripple Creek Gold Mining District of Colorado." The paper was illustrated by about thirty lantern views, most of which were taken by the speaker during the past summer, and by an extensive series of rocks and ores. After a brief historical review the region was described in detail, without, however, introducing anything essential that is not already contained in the Cripple Creek Atlas folio of the United States Geological Survey, which was prepared by Messrs. Cross and Penrose.
J. F. KEMP, Sec'y.

GEOLOGICAL SOCIETY OF WASHINGTON.

At the 42d meeting, held on Jan. 29th, Prof. C. R. VAN HISE spoke on "*The relations of primary and secondary structures in rocks*," being a continuation of the subject considered at the preceding meeting. The relation between cleavage and fissility was discussed. It was concluded that fissility in many cases is controlled in its direction by a previously developed cleavage. Further, most rocks, at the surface having the property of cleavage which developed under deep seated conditions, show to a greater or less degree a fissility developed when they were nearer the surface.

The relations of the secondary structures, cleavage and fissility, to bedding were considered. It was shown that there is a tendency for the primary and secondary structures to become parallel or nearly so on the limbs of folds and to intersect each other at the arches and troughs. In case the folding is close the two structures may be so nearly parallel, except at the short turns of the anticlines and synclines, that the fact that there is a discrepancy anywhere is apt to be overlooked and the conclusion reached that in a given district the two structures are everywhere accordant. This mistake in the past has frequently led to great overestimates of the thickness of formations having slatiness or schistosity.

Prof. Van Hise's observations and conclusions were corroborated and supported by Messrs. Diller, Willis and Keith.

W. F. Morsell.

IOWA GEOLOGICAL SURVEY.

The annual report of the state geologist of Iowa, for the year 1895, has been submitted to the Board and ordered printed. It includes, in addition to the usual administrative papers, reports upon six counties. Jones county is reported upon by Prof. Calvin. He divides the Niagara series of the Silurian into four divisions: (1) Delaware stage, (2) Le Claire stage, (3) Anamosa stage, (4) Bertram stage. The Le Claire is characterized by a large number of local dips which are interpreted as the result of cross-bedding. The Anamosa stage includes the heavy limestone beds which have been so extensively quarried. Dr. S. W. Beyer, in his report upon Boone county, has mapped the inner moraine of the Des Moines lobe. This is shown upon the first of the Pleistocene maps published by the Iowa Survey. In Warren county Prof. J.L. Tilton has paid especial attention to the physiography. He thinks that the Des Moines river is a subsequent stream, and that North, Middle and South rivers are obsequent. In Washington county Mr. H. F. Bain has studied the relations between the Devonian and the Carboniferous. It seems probable from these studies that what has been known as the Kinderhook shale may be the southern extension of the Lime Creek shales which contain a prolific Devonian fauna. In the report upon Woodbury county Mr. Bain has summarized the work upon the Cretaceous in Iowa and has reviewed the historical controversy which arose during the formation of the "Upper Missouri section." In Appanoose county he has mapped the known areas underlain by the Mystic coal and has gone quite fully into the various problems connected with the mining of this bed.

It is announced that volume VI will shortly be ready for the press. It is expected to contain a full report on the artesian wells of the state by Prof. W. H. Norton, as well as a paper by Dr. Beyer upon the Sioux quartzite and certain associated rocks, and a report upon the lead and zinc deposits of Iowa by Prof. A. G. Leonard.

THE

AMERICAN GEOLOGIST.

Vol. XVII. APRIL, 1896. No. 4.

APPARENT ANOMALIES OF STRATIFICATION IN THE POSTVILLE WELL.

By Samuel Calvin, Iowa City, Iowa.

A well recently bored at Postville, Iowa, reveals some interesting geological phenomena that may not be unworthy of consideration by those who have occasion to interpret the records preserved by drillers of deep wells. The well in question was bored to supply the incorporated town of Postville with water. Postville is located in the southwest corner of Allamakee county, near the margin of the *Driftless Area*. There is some drift in the neighborhood; but the superficial deposits within the limits of the town are such as were laid down along the free margins of the Iowan ice sheet, and consist of loess and sub-loessial sands, which here overlie residual clays and cherts derived from the preglacial secular decay of the Galena limestone. Beneath Postville the indurated rocks are, first, Galena limestone; second, Trenton limestone; third, Saint Peter sandstone; fourth, the different members of the Oneota limestone, embracing the equivalents of the Shakopee limestone, New Richmond sandstone and Main Body of limestone of the Minnesota geologists; and fifth, the Saint Croix sandstone, the upper part of which includes the Jordan sandstone and St. Lawrence limestone as described in the geological reports of Minnesota. The formations named are all exposed in the bluffs along the Yellow river. The stream flows in a deep, cañon-like valley, which may be reached about four miles north of Postville. Immediately north of the town, however, the river has not cut quite through the Trenton, but by following down the channel the formations lying beneath the Trenton are seen in orderly succession.

At Postville, and in the valley of the Yellow river north of the town, the Trenton limestone attains an unusual thickness. Between the Buff beds, that are undoubtedly Galena, and the top of the Saint Peter sandstone there occurs the following section, the measurements being closely approximate but not exact.

	Feet.
8. Blue clay, unfossiliferous	5
7. Thin-bedded argillaceous limestone, no fossils	5
6. Bluish shales with some fossils	5
5. Thin-bedded, gray, shaly limestone, fossiliferous	60
4. Blue, fine-grained limestone, weathering to buff, with many thin beds of shale near the top and frequent beds of yellowish, argillaceous limestone	200
3. "Green shales," with many thin layers of very fossiliferous limestone: containing *Orthis subæquata*, *O. tricenaria*, *O. bellarugosa*, *Strophomena filitexta* and other brachiopods in the lower part, and many individuals of *Prasopora simulatrix* and related bryozoans in the upper part	40
2. Heavy bedded, magnesian limestone. Lower Buff beds of the Wisconsin geologists	25
1. Basal shale resting on Saint Peter sandstone	5
Total	345

Number 4 of this section contains the "Blue limestone" that is generally counted as the typical portion of the Trenton. The Minnesota geologists, however, have sometimes regarded the "green shales" as the upper limit of the Trenton, and have referred all Lower Silurian sediments above No. 3, of the preceding section to the Galena limestone and Hudson River, or Maquoketa shales.* At Postville, Iowa, the Galena proper is represented by buff, dolomitic beds that overlie all the limestones and shales exposed in the section described. South of Postville the Galena passes beneath the true Maquoketa, or Hudson River beds, while a little farther south, as for example at the Williams' quarry, the shales in turn disappear beneath outliers of the Niagara. It would seem, therefore, notwithstanding their extraordinary thickness, that the whole aggregate of sediments included in numbers 1 to 8 of the section must be referred to the lower division of the Trenton

*Geology of Minn., vol. I of the Final Report, p. 293, 1884.

series, the division commonly known in western geology as the Trenton limestone. All previous measurements of the thickness of the sediments between the base of the Galena and the upper surface of the Saint Peter fall far short of the 345 feet disclosed by the Postville section. Furthermore, these older measurements indicate a very remarkable range of variation in the thickness of this part of the geological column. For example, Hall's section at Clayton City* shows only about 20 feet of Trenton, while that at Guttenberg,† only eight or ten miles southeast of Clayton, shows 116 feet between the Galena and the Saint Peter. Strong makes the Trenton in the lead region of Wisconsin fifty feet thick,‡ while White§ reports the thickness of the Trenton along the Mississippi as eighty feet, and in Winneshiek county as upwards of 200 feet.

That the thickness of the Trenton in Winneshiek county is more than 200 feet is quite certain: for in the great vertical cliff at Bluffton there is an exposure of more than 150 feet, made up wholly of limestone beds belonging to No. 4 of the Postville section. The Bluffton cliff exposes neither the bottom nor the top of this member of the Trenton, and yet between Bluffton and a point three miles below Decorah the lower portion of number 4 and the whole of numbers 1, 2 and 3 are exposed and shown to be fully developed. There are at least eighty or ninety feet of Trenton below the beds exposed at Bluffton, and that the beds corresponding to numbers 5 to 8 inclusive are present in considerable force, is attested by many observations, though the exact thickness of the beds has not been ascertained. In the report on the Geology of Allamakee county‖ the writer made the total thickness of the Trenton about 300 feet, the thickness of No. 4 of the Postville section having been measured in the eastern part of the county where it is at least 50 feet thinner than in Winneshiek and southwestern Allamakee. According to Norton¶ the well records in eastern and northeastern Iowa demonstrate that

*Hall's Geology of Iowa, vol. I, part 1, p. 56, 1858.

†Ibid., p. 58.

‡Geology of Wisconsin, vol. II, p. 680, 1877.

§Geology of Iowa, vol. I, p. 175, 1870.

‖Iowa Geol. Surv., vol. IV, General Description of the Trenton, pp. 74-77, 1895.

¶Iowa Geol. Surv., vol. III, p. 180, 1895.

the combined thickness of the Galena and Trenton is quite uniform and that it does not vary much from 400 feet. In a general way the places where the observed thickness of the Trenton is least correspond to localities in which the Galena attains its maximum development. It is probable, therefore, that the two formations together represent a single stratigraphic unit and that the conditions favorable to the formation of dolomite did not appear simultaneously over the area of sedimentation. In certain favored centers these conditions were introduced early, in others they were delayed till near the close of the epoch represented by the two formations combined. In certain localities the Trenton is only from 50 to 100 feet in thickness: in others 350 feet of sediments accumulated before the process of forming dolomite began. The thickness of the Galena limestone, so far as it is exposed in Howard and Winneshiek counties, and in the vicinity of Postville in Allamakee county, is less than fifty feet, while the shales and limestones, below the Galena and above the Saint Peter, attain a maximum thickness of about 350 feet. Between Postville and the mouth of the Yellow river the Trenton is very much thinner than in the western part of Allamakee county, and the thickness of the Galena is correspondingly increased: the increase apparently taking place partly at the expense of number 4 and partly at the expense of the shales and shaly limestones overlying that member of the section.

In the Postville well the shales in the upper part of the Trenton were reached at a depth of eighty-five feet from the surface. Three hundred and fifty feet lower the drill entered a sandstone at a depth from the surface of 435 feet. The position of the sandstone and the clean, limpid, water-worn and polished grains of quartz sand brought up by the slush bucket left no possible doubt that the Saint Peter had been reached, but for some reasons it seemed to be to the interest of certain persons to deny that the sand came from the Saint Peter sandstone. Boring proceeded, and at 448 feet from the surface the samples obtained showed practically pure Saint Peter sand. At 452 feet the most interesting anomaly which this interesting well presents was encountered. The sandstone suddenly gave place to what the well driller calls a mud rock and the progress of the work proved the "mud rock" to have a thickness of about sixty feet. The drillings obtained showed the material to have the same color and chemical composition as the argillaceous and calcareous shales making up the "basal shales" No. 1, and the "green shales" or No. 3 of the preceding section. At 512 feet from the surface the samples proved that the drill had again entered the Saint Peter sandstone. Drilling proceeded to a depth of 515 feet and then stopped, the supply of water being sufficient for the purpose for which the well was made. That the clear quartz sand taken at depths of 512 and 515 feet from the surface belonged to the stage of the Saint Peter sandstone was not, in this instance, disputed.

If the sandstone between 435 feet and 450 feet from the surface does not belong to the Saint Peter stage then a number of serious difficulties present themselves. First, the facts would have to be interpreted as indicating a bed of sandstone interstratified with the Trenton, but field observations have never shown any arenaceous beds between the top of the Saint Peter and the base of Galena. The Saint Peter sandstone ends abruptly and the lower Trenton shale begins without any intermingling of characteristics belonging to the two formations. There are no transition beds in the lower part of the Trenton and there are no known sandstone layers at any horizon within the limits of the Trenton series. Second, the facts would indicate that the Trenton shales and limestones have a thickness of more than 425 feet, a thickness wholly inconsistent with any observations made in the field. A thickness of 350 feet is so far in excess of measurements published by the earlier observers as, at first, to justify serious doubt respecting the reliability of the data on which it rests. Observations were repeated more than once before it was considered safe to publish the figures given in the report on Allamakee county, and that report, while making the total thickness of the Trenton 100 feet greater than the dimensions given by any previous publication, did not give the full measurements afforded by the several members of the section where they attain their maximum development. Third, the assumption that the arenaceous layer reached at 435 feet is not Saint Peter is inconsistent with field observations in another particular. The Saint Peter sandstone is exposed in the valley of the North fork of the Yellow river about eight miles northeast of Postville. Its upper surface, as determined by surveys made in connection with the topographic work on Allamakee county, has an elevation of 877 feet above sea level. Other exposures in the same neighborhood show that the strata here dip to the southwest at the rate of twelve to fifteen feet to the mile. Assuming the greatest observed dip to be correct and constant, the elevation of the Saint Peter at Postville should be 757 feet. Exposures of the upper surface of the sandstone at Volney, Smithfield and Werhan's mill, have a dip which, if projected to Postville, would make the elevation of the sandstone a few feet greater than the figures given above. The elevation of the mouth of the well is 1,191 feet above sea level, and hence the depth from the surface at which the sandstone might reasonably be expected, judging from its position and dip in the nearest natural exposures, can not much exceed 434 feet. The point at which the sand was actually reached had a depth beneath the surface of 435 feet. The depth accords well with all field observations and is inconsistent with none.

On the other hand, however, if the arenaceous bed at 435 feet from the surface is Saint Peter sandstone, then we are confronted with the anomaly of sixty feet, or more, of material in all respects similar to the argillaceous and calcareous shales of the Trenton, apparently interstratified with the sand of the Saint Peter, and occupying the greater part of the space that properly belongs to this formation. Nowhere in the natural exposures, so far as observed, are there any indications of calcarerous shales interbedded with Saint Peter sandstone. Field records do, however, show that the Saint Peter is especially liable to become cavernous. The materials composing the deposit are so incoherent that mechanical erosion acts with great effectiveness in dislodging and transporting the rounded, polished, uncemented, quartz grains. Since the region was elevated above sea level, underground waters have cut channels in the sandstone, and some of these channels were formed near the base of the formation. Owing to the low degree of cohesion among the constituent grains, gravity alone is sufficient to cause the walls and roof of any one of these channels to crumble and fall. The sand so falling is removed by the subterranean current. More takes its place from above to be in turn carried away; and thus in time caverns of large dimensions may be formed in the sandstone by means purely mechanical. That caverns are so made is clearly shown at a number of exposures. About one mile south of Werhan's mill, and about seven miles north of east from Postville, there is a large natural cavern in the Saint Peter, opening by a relatively small entrance into the side of the bluff from the level of the roadway. The chamber is at least sixty by forty by twenty feet in dimensions. A little sand may have been hauled away from here for building purposes, and some small amount of artificial excavation may have been made in adapting the cavern to its present use as a great natural cow-shed, but the chamber, in its main features, illustrates the possibilities of cave formation, by mechanical erosion, in this particular formation. The arching roof of the cave is of sandstone, in which the grains are cemented together by calcareous material carried down by infiltrating waters during the process of solution and removal of the overlying Trenton limestone. The bond is just sufficient to enable the arch to stand in opposition to gravity. The roof of the cavern is intact. The only opening is from the side. The erosion of the valley, which is followed by the roadway, barely cut into the edge of the natural excavation.

On the farm of Mr. James Dougherty in French Creek township there is another cavern in the Saint Peter sandstone even more suggestive than that just described. In this case the opening, a few yards in diameter, is from above. The cave is entered by means of a ladder. The chamber is some forty to sixty feet in diameter. It is over-arched by a dome-like roof of sandstone, the roof being complete except for the small opening through which entrance is effected. This cave has probably been excavated since the Trenton, that originally overspread the region, was removed. At all events, the opening in the roof is comparatively recent, and has been formed since the disappearance of the limestone.

Many other caves in the sandstone bear testimony to the fact already stated that the Saint Peter is especially liable to become cavernous, but those already noted will serve for purposes of illustration. Erosion by underground streams may begin anywhere below the upper surface of the formation and may result in producing a dome-shaped cave; the friability of the deposit in its lower portions affording the conditions favoring the easy removal of material, and the calcareous cement in the upper portion furnishing the conditions necessary to the maintenance, for some time, of a stable roof.

Now, if a cavern like that on the Dougherty farm is formed in that portion of the sandstone which is still overlain by the Trenton, it may for a long time remain as an unfilled space; but when the summit of the arched roof opens through to the basal part of the Trenton, the descending waters will at once proceed to fill the chamber with the argillaceous and calcareous shales from numbers 1 and 3 of the Trenton section.

The Postville well samples taken between 450 and 512 feet in depth are all of such material as might have come from the shaly members of the overlying Trenton. All apparent anomalies, therefore, are explained by the admission of a cavern at this particular point, in the Saint Peter sandstone; a cavern in which the arching sandstone roof was finally broken through up to the base of the Trenton, and into which easily erosible material from the overlying limestone formation was carried by descending ground waters, until the entire space was filled with the "mud rock" that was such a puzzle to one of the most observant and intelligent of well drillers. This explanation is in entire accord with known facts derived from observations in the field. It is inconsistent with none.

From the very nature of the case, caverns in the Saint Peter sandstone beneath the Trenton must be of common occurrence, and the scores of deep, hopper-shaped sink holes that are so characteristic a feature of regions occupied by the overlying limestone* show that descending waters have carried away enormous quantities of erosible Trenton material to be deposited somewhere along the course of the underground streams.†

*Iowa Geol. Sur., vol. IV, p. 78, 1895.

†Mr. John H. Dickson, of Luana, Iowa, has bored a number of wells throughout an extensive area in which the geological structure is essentially the same as at Postville. From what is known of the Saint Peter sandstone at its natural exposures it seemed that the peculiar conditions disclosed by boring the Postville well are sufficiently numerous to make it very probable that other wells might encounter the same conditions. Mr. Dickson, in response to inquiries, writes: "In the Tewes well, three miles east of Monona, we had such an opening only in a smaller degree, and in referring to my well-book I find, in one case in Crawford county, Wis., we had a similar case, only the color was buff, the same as above the sandstone about 30 to 40 feet. We had to go back to this well three times to take up the pump, and finally had to put in 66 feet of smaller casing to hold the walls in proper place."

Caverns are indeed common in all formations, and cases analogous to that indicated by the Postville well can be easily recalled by every observer. The occurrence at Davenport of Carboniferous shales between beds of Devonian limestone, as described by Hall and Barris, and the similar shales, described by Farnsworth, at Clinton in caverns excavated in the Niagara dolomite, demonstrate the possibility of numerous apparent anomalies of stratification in well records, and at the same time suggest, for some of them at least, a very natural and simple explanation.

ENGLACIAL DRIFT.

By W. O. Crosby. Boston, Mass.

Introduction.

Among the unsolved problems of glacial geology none, perhaps, are more important or pressing at the present time than the relative abundance and significance of the englacial drift. Although this subject has received its due share of attention in the recent literature of the science, the views of the leading glacialists are still strongly contrasted. Thus Chamberlin and others hold that the englacial drift was exceedingly scanty in amount, consisting chiefly of a few far-travelled, angular and unglaciated bowlders now scattered over the surface of the drift; while Upham, the foremost exponent of the opposing theory, finds in the englacial drift the chief source of all the manifold forms of modified drift and also of drumlins.

The arguments of those who minimize the englacial drift are based chiefly upon the local character of the drift, the supposed paucity of englacial drift in modern glaciers, and the mechanical difficulty of accounting for a differential upward movement in the ice-sheet whereby large volumes of basal drift or ground moraine became englacial. The cogency of these arguments is beyond question; and a careful study of the recent literature satisfies me that, as the case now stands, the *onus probandi* may fairly be said to rest upon those who regard the englacial drift as an important factor in Pleistocene geology. Still, the englacial drift accounts so satisfactorily for far-travelled erratics, and the derivation from it of the modified drift is, theoretically, so relatively direct and simple, that faith in its sufficiency cannot be lightly relinquished.

In his recent paper on the "Discrimination of Glacial Accumulation and Invasion,"* Upham has, it seems to me, made a substantial contribution to the general theory of the Pleistocene ice-sheet; and my chief purpose now is to analyze this idea that the ice-sheet was, over a considerable part of the glaciated area, formed *in situ* by snow accumulation, trace it to its logical conclusions, and show that it also throws important light upon the more special problem of the englacial drift.

PROBABLE EARLY HISTORY OF THE PLEISTOCENE ICE-SHEET.

In this discussion a sharp distinction may properly be made between mountainous tracts, like the Adirondacks, Green Mountains, and White Mountains, and the plain or peneplain surface characteristic of the greater part of the glaciated area. The first-named topographic type, although the more exceptional, may conveniently be considered first.

In mountainous districts, or where the relief features are so strongly accentuated as to cause appreciable climatic differentiation, the general refrigeration of the climate, due chiefly, it is probable, to a marked elevation of the northern part of the continent, led first to the development of glaciers of the alpine type in the higher valleys. These descended, under the influence of gravity, below the climatic zone in which they originated; as the level at which terminal ablation balanced the downward movement was gradually lowered, they became confluent; and finally, emerging from the mountains, they deployed upon the plain country, forming relatively sluggish or stagnant piedmont glaciers. But the extension of the piedmont glaciers by simple invasion can not continue indefinitely for the reason that with progressive refrigeration the annual snowfall finally exceeds the annual melting over the plain country as well as the mountains; at first near the margins of the piedmont glaciers only, but gradually extending farther and farther from them.

This cumulative snowfall, which mantled alike hills and valleys, and changed slowly through névé to glacial ice, must

*Bull. Geol. Soc. of America, vi, 343-352.

have tended in some measure to check or arrest the motion of the ice which had flowed outward from the mountains. Owing, however, to the forward motion of the piedmont glaciers, as well as to their termination on tracts where a short time before ablation had been in excess of snowfall, they must have terminated somewhat abruptly or with high marginal gradients; and the conditions were, therefore, extremely favorable for their overriding the new and still stationary ice-fields by which they were invested, in the manner indicated by the experiments of Favre, Bailey Willis, and others, on the compression and folding of sedimentary deposits of unequal thickness or rigidity.* The overridden tract or zone of ice must slowly acquire the motion of the overriding sheet, and thus in its turn come to override other tracts. In fact, it seems to me very probable that this process of overriding and absorption would continue almost indefinitely, extending, possibly, over a large part of the glaciated area. The only alternative views are that the piedmont glaciers became stationary, or that they were able by simple thrust to induce motion in the embryo and still sedentary ice-sheet across a breadth of hundreds of miles. The theory of overriding lies between these extremes.

Assuming a uniform annual snowfall over the area of the sedentary ice-sheet, it is obvious that since its area is gradually extended southward by the progressive climatic refrigeration, while the annual ablation as gradually diminishes northward, its thickness must increase backward from the margin. To the surface gradient thus resulting must be added the southward gradient of the surface of the land, which was probably augmented by differential continental uplift.

If, as Upham holds,† and as certainly seems most probable, the precipitation of snow over the growing ice-sheet was not uniform, but greatest for the first 100 to 200 miles inward from the margin, the surface gradient must have culminated on these peripheral tracts, diminishing gradually backward. This condition would, obviously, favor an early beginning of outward movement or flow in the marginal zone, and tend in an equal degree to retard motion in the central area.

*See also Upham's paper on "Drumlins and Marginal Moraines of Ice-sheets." Bull. Geol. Soc. of America, VII, 22.

†Bull. Geol. Soc. of America, VI, 344.

It seems a reasonable assumption that the period of the growth and culmination of the ice-sheet, equally with that of its waning and disappearance, must have witnessed marked climatic oscillations of long period. In fact, we would hardly be justified in supposing that the great crustal movement which gave us the Ice age was steadily progressive, without interruption or reversal, until its final culmination. During each period of climatic amelioration and increased ablation of the sedentary ice-sheet, its margin must have retreated to the northward; and since the ablation must have rapidly diminished northward, snowfall exceeding ablation within a few miles of the margin, we have here another efficient cause of a high marginal gradient. That is, precipitation and ablation coöperate to accentuate the frontal slope of the ice-sheet. Now the chief factors in determining movement of the ice-sheet were, undoubtedly, its thickness and marginal gradient. We have few reliable data derived from observations on modern ice-sheets to indicate the magnitude which these factors must attain to inaugurate movement in an ice-sheet formed *in situ* over such a dissected peneplain as is presented by the surface of a large part of Canada and the northern United States, many of the valleys having contrary or transverse directions. But the absence from a large part of the glaciated area of mountains or dominant hights of land requires us to assume that over considerable tracts the sedentary ice-sheet did eventually begin to flow without having experienced the overriding or shearing thrust of the piedmont ice-fields. The outward movement thus originating in the peripheral tracts during a period of excessive ablation must have extended backward, perhaps until it met the forward thrust of the piedmont glaciers.

During a period of active growth of a sedentary ice-sheet, each annual snowfall advances its margin, and increases its thickness by amounts depending upon the distance from the margin. Although the zone of maximum precipitation does not necessarily coincide exactly with that of most rapid growth or maximum excess of precipitation over ablation, we may assume that they would not be widely separated, and that the locus of most rapid growth would, therefore, be found at a moderate distance, say 100 to 200 miles from the margin.

If we could only know the normal ratio of vertical to horizontal or areal growth, we might, assuming that climatic oscillations began at an early period of its history, reach a definite conclusion as to the probable extent of the ice-sheet when it first began to move or flow outward. We may, however, attack the problem in another way. The equivalent of one foot of ice is, perhaps, not too large an estimate of the average annual excess of precipitation over ablation on the zone of maximum growth. Warm periods may arrest and reverse the areal growth while the central tracts continue to increase in thickness, though possibly at a diminished rate, thus accentuating the frontal slope. That is, while cold periods must mean, on a plain country, relatively rapid horizontal growth and therefore a growth unfavorable to early movement, the ice-sheet becoming proportionally thinner; a moderately warm period, following a cold one, means continued growth in thickness with a great reduction of area, and hence a growth especially favorable to early movement, the ice-sheet becoming proportionally thicker. It seems probable, therefore, that a warm period following a cold period of two or three thousand years duration would induce movement in the sedentary ice-sheet, and that movement at this early period might affect almost simultaneously the peripheral and central tracts.

Assuming now that movement of the ice-sheet was inaugurated during a warm period, and that the southern margin of the ice has retreated far to the north through ablation, developing a bold and aggressive front; it is obvious that the succeeding cold period must have caused a rapid extension of sedentary ice southward from the front of the moving sheet; and the former would inevitably be progressively overridden and absorbed by the latter. It may be noted, also, that these phenomena would be repeated with each recurring climatic cycle. This section may be summarized as follows:

The Pleistocene ice-sheet was formed *in situ*, by snow accumulation, over the main part of the plain country within the glaciated area. The motion which this sedentary ice-sheet subsequently acquired probably originated in several ways:

1. In the vicinity of the mountainous tracts, through its being progressively overridden and absorbed by piedmont glaciers.

2. At a distance from mountains and independently of piedmont glaciers, by the steepening of the marginal gradient, chiefly through increased ablation due to climatic amelioration.

3. The cold period following each period of marked climatic amelioration and consequent recession of the margin of the ice-sheet must have spread a new sedentary ice-sheet over the deglaciated area, which would be progressively overridden and absorbed by the re-advance of the older sheet.

Basal Relations of a Sedentary Ice-sheet.

During the slow accumulation of the ice-sheet, and before it began to move, the ground beneath it, which must have been saturated with water, was probably frozen solid to a considerable depth, possibly nearly if not quite to the bottom of the residuary soil or other surface detritus; that is, down to the firm rocks. There could have been no original plane of separation or movement between this frozen soil and the overlying ice-sheet; for the ice did not merely rest *on the detritus*, but extended down through it to the lower limit of frost. This point will probably be conceded by all who have noted the tenacity with which ice in winter adheres to the ground, pavements, etc., when the temperature is below freezing.

Ice, in the thin sheets with which we are familiar, separates readily from the underlying soil in mild weather, while the subsoil still remains frozen, for the simple reason that the solar heat passing downward through the ice is arrested by the surface of the ground, causing a local rise of temperature along the contact between the ice and frozen soil. The operation of this principle evidently depends upon the thermal diaphaneity of the ice; and hence it does not, in general, admit of application in the case of snow, which is relatively opaque to both light and heat. Therefore this cause of separation can not be invoked in the case of the growing ice-sheet of the Glacial period, since it was a necessary condition of its formation that the winter snows remained unmelted upon its surface, accumulating thus to a great thickness and slowly changing downward through névé to glacial ice. We must suppose, then, that from the top of the ice-sheet to the lower limit of frost in the soil was one solid mass,—ice above, and ice and soil below.

It may safely be assumed that over the glaciated area in preglacial times, as now in lower latitudes, the superficial detritus or soil was chiefly the residuary product of quiet chemical decay. This is equivalent to saying that it consisted chiefly of clay and sand. Hard angular fragments of rock, such as are so common in the till, were wanting; and the rounded bowlder-like nuclei of decomposition must have been of rather rare occurrence at points near the surface of the ground, or above the lower limit of the frost.

If we may assume a thickness of residuary detritus commensurate with that which now mantles the Southern States, it is, perhaps, probable that over considerable areas solidification by freezing would fail to reach the firm, undecomposed rocks beneath. However that may be, it is certain that with increased thickness the ice-sheet became a more and more efficient protection to the ground against the climate of the Ice age; and the steady efflux of heat from the earth's interior would thus tend to gradually loosen the hold of the frost upon the rocky substratum.

Observations in the Arctic regions and at high altitudes show that the ground may become frozen to a depth of several hundred feet; and R. S. Woodward's theoretical discussion* of the subject not only corroborates these observations, but indicates that the downward penetration of the frost may be comparatively rapid. Thus, if the mean annual temperature of the surface should fall from 60° F. to 10° F. the ground would become frozen to a depth of 400 feet in less than 1,000 years. Russell suggests† that the great depth of frozen soil reported at Yakutsk, Siberia (382 feet), and at other arctic stations, may be due in part to the surface accumulation of ice through the growth of the tundra, and that possibly the rate of diffusivity of temperature assumed by Woodward is too high; but he does not seriously question the main conclusion with regard to the efficiency of frost penetration.

It is well known that glaciated areas are not, in general, those of most extreme cold. A humid climate is the first essential; and, given that, a temperature low enough throughout the year to insure precipitation chiefly in the form of

*Bull. Geol. Soc. of America, I. 130-132.
†Ibid.

snow and to prevent excessive waste by summer melting—a mean annual temperature a few degrees only below freezing, like that on the Mount St. Elias coast of Alaska—is all that is required for active glaciation. In harmony with this conclusion we find that the extremely frigid areas, such as the interior of Alaska and northern Siberia, are relatively dry and non-glaciated. For this reason, and also because the increasing thickness of a sedentary ice-sheet would tend to neutralize the downward penetration of frost, we need not suppose that the ground beneath the ice would be frozen to any great depth or far below the detrital layer.

The relatively high conductivity and diffusivity of pure ice, in comparison with the covering of névé and snow, would tend, through the steady efflux of the terrestrial heat, to raise the temperature of the lower portion of the ice-sheet to the melting point. On the other hand, the high latent heat of fusion would tend to prevent extensive melting of the ice until the entire basal portion of the sheet had attained approximately the melting temperature. The effect of the weight of the ice itself in lowering the temperature of fusion of its base would be too small to require consideration here.

The interesting question now arises as to the most probable plane of shearing when the sedentary ice-sheet finally begins to move. We may assume that the initial basal shearing or gliding plane will be approximately the same whether the ice-sheet begins to move in obedience to its own weight or through the overriding thrust of a thicker northern sheet. In any case, or whatever the cause of movement, it is, as we have seen, most likely to be inaugurated during a period of climatic amelioration. Above the bed-rock, three layers of material require consideration: (1) The ice-sheet proper; (2) the frozen soil beneath it, to which it is still firmly united; (3) the unfrozen soil resting upon or passing downward into the solid rocks. Under the assumed conditions of climatic amelioration and a basal rise of temperature in the ice-sheet, we may suppose that the frozen soil, in consequence of its lower position and the relatively low specific heat of earthy and stony substances, would tend to rise in temperature and to thaw earlier than the pure ice. Hence the frozen soil may, perhaps, be regarded as weaker and more susceptible of shearing than the clear ice, although at temperatures well below freezing the reverse relation would probably hold true. We thus arrive at the conclusion that at the inception of movement in any part of the ice-sheet the ice is possibly stronger than, but essentially continuous with, the frozen soil, and the latter is clearly stronger than the unfrozen soil; and hence it would follow that the most probable initial plane of slipping or shearing would be in the unfrozen soil, the frozen soil and overlying ice moving *en masse*, and the movement being lubricated by the unfrozen soil, which would be at most points of an argillaceous and plastic character. Although a residuary soil naturally becomes firmer and more rock-like downward, and is, therefore, weakest near the surface, we should not lose sight of the fact that, since frost causes a notable expansion of the soil, a recession of the lower limit of the frost toward the surface, through the efflux of the terrestrial heat and consequent rising of the isogeotherms, would tend to leave at the lower surface of the frozen soil a thawed-out layer of loose and yielding texture.

Observations heretofore made on modern glaciers and ice-sheets are of little value in this connection, because nowhere in the field of observation are realized the conditions that must obtain at the base of a sedentary or recently sedentary ice-sheet. The true glaciers or ice rivers of alpine districts, Greenland, etc., are mere lobes of ice descending under the influence of gravity from the edges of névé fields and ice-caps into a climatic zone where permanent ice cannot form; and hence they are moving over unfrozen soil, and the ice is wasting by melting on its under as well as its upper surfaces. The great desideratum is, evidently, a shaft or boring in the interior of Greenland extending through the entire thickness of the ice-sheet and a hundred feet into its rocky bed. This would expose the true basal relations, thermal and otherwise.

In his recent paper on the "Influence of débris on the flow of glaciers,"* Prof. Russell assumes that ice is analogous to pitch in that its plasticity or tendency to flow is diminished by enclosed débris. This assumption is undoubtedly safe for temperatures well below freezing. But if it is a sound principle that when the temperature of the ice is rising and near

*Journal of Geology, III, 823-832.

the melting point, the enclosed rock débris will, on account of its lower specific heat, tend to rise in temperature faster than the ice and thus to loosen by melting the bonds between it and the ice, then the comparison with débris in pitch would seem to hold good only in the improbable case when the imbedded stones caused a local softening of the pitch. The débris in ice would not lead to extensive melting on account of the high latent heat of melting ice. But if the temperature of the débris rises ever so little above 0° C. (32° F.) it ceases to be a source of strength in the ice, the effective section of the ice being diminished in proportion to the amount of débris. This view seems to be abundantly confirmed by Prof. Chamberlin's Greenland studies, for he has given us no more striking and significant fact than the relative facility with which the ice shears along innumerable lines of débris; and the evidence is conclusive that the ice, to a large extent, slides over the enclosed débris, instead of dragging it along, as it would if the débris were firmly frozen into the ice. Granting, however, that the frozen soil would be more rigid and indifferent to gravitative stresses than the clear ice above it, the fact remains that the unfrozen soil at the base is more yielding and plastic than either; and hence, although we may reasonably conceive definite shearing planes as distributed through a considerable thickness of the ice-sheet, the lowest plane, and the true base of the ice-sheet, will still be at the lower limit of frost.

So far as I can learn, everywhere within the range of observation modern glaciers are either sliding over their ground moraines, or they rest directly upon the firm bed-rock; just as many rivers, at ordinary seasons, flow quietly over deep beds of gravel and stones or over bare ledges. In both cases active erosion of the bed-rock floor is nearly at a stand still; for where it is not protected by the stagnant débris the ice or water are not well suppled with stones, without which they can do little. In the case of the river, periods of flood, or of greater fall or volume in the past, must be postulated to set the detritus in motion and account for the effective erosion of their channels. Similarly for the glacier, the entire ground moraine must be set in motion. Increased thickness and velocity of the ice would probably tend to accomplish this. But to my mind rectilinear striæ, often scores of feet in length, are an impossibility unless we conceive the entire mass of the ground moraine as enclosed in the moving ice.

Professor Chamberlin's observations in Greenland show that any number of horizontal shearing planes may be postulated, with a corresponding reduction of the basal velocity; but I see, with Upham, no escape from the conclusion that during the period of active and efficient glaciation of the bed-rock surfaces, the ground moraine was very scanty or wholly wanting, being incorporated with the moving ice. Imagine a modern glacier or ice-sheet as launched upon a plain covered by 25 to 50 feet of sedentary detritus passing gradually downward into firm rocks, and consider how little chance there would be for the development on the underlying bed-rock of a typical glaciated surface, so long as the ice and soil are essentially distinct. The preliminary removal of the detritus by simple thrust and drag is seen not to be a valid explanation when we consider the great breadth of the glaciated area, and the enormous marginal accumulation which would inevitably result. A true ground moraine between bed-rock and ice, and distinct from both, belongs to the waning stage of the ice-sheet and to lobes of ice (glaciers) descending from an ice-cap or névé field into a climatic zone where permanent ice cannot form.

All this appears to be quite consistent with the local origin of the greater part of the till or ground moraine of the Pleistocene ice-sheet and the well-established fact that the total movement of the ice amounted to hundreds of miles, if we simply suppose that through the granular plasticity of the ice, or a series of shear planes, the basal, drift-laden layer moves much more slowly than the overlying clear ice.

ABSORPTION OF DRIFT BY THE PLEISTOCENE ICE-SHEET.

Glacialists are sharply divided in opinion as to the power of an ice-sheet to absorb or incorporate with its mass the detritus over which it moves; and the arguments pro and con have been stated with much fullness and force in recent papers by Upham, Chamberlin, and others.* It is clearly incumbent upon the advocate of the englacial theory to prove

*Upham has recently cited all the more important of the later contributions to this discussion. (Bull. Geol. Soc. Amer., v, 72, 73.)

that large volumes of drift may become englacial. It seems to me that this has not been satisfactorily done as yet, and, as previously stated, the chief purpose of this paper is, if possible, to reënforce the englacial theory at this point.

The sedentary ice-sheet, as we have seen, holds in its grasp a large part of the surface detritus; and if, as I believe, the initial shearing plane is normally or usually at the lower limit of frost, a considerable body of detritus, mostly of a fine or impalpable character (preglacial residuary soil, etc.), is englacial from the beginning of movement of the ice-sheet. When a sedentary ice-sheet is overridden by a piedmont glacier, and still more when a sedentary ice-sheet is overridden by the reädvance of an earlier ice-sheet, the conditions must be favorable for the transfer of drift from the base of the earlier sheet to a somewhat elevated position in the composite sheet which results from the overriding. We may suppose that the overriding sheet will carry with it not only its own englacial drift, but will drag along, also, a part of its ground moraine or subglacial drift. This complex process will be repeated with each marked recession and reädvance of the ice-sheet.

It is altogether probable that each important recession of the ice-sheet, and not alone the final recession, was characterized by numerous glacial rivers and lakes and an extensive development of modified drift in the well known forms of kames, eskers, deltas with abrupt northern margins, etc. It is obvious that such eminently loose and porous deposits would be completely permeated by and form an essential part of the succeeding sedentary ice-sheet. Thus material which may have slowly become englacial through the movement of an earlier ice-sheet is englacial from the beginning of the succeeding sheet. Or, if the later ice should move over these deposits, their forms and structures are very favorable to their being absorbed by the ice through shearing and flexing.

Some of the illustrations accompanying Prof. Chamberlin's valuable description of the Greenland glaciers* are well calculated to dispel any doubts that may exist in the minds of geologists as to the power of a glacier to absorb detritus by

*Journal of Geology, III, 478, figs. 28-30. Bull. Geol. Soc. Amer., VI, 203-214, plates 5-9.

shearing and flexing movements. The flexures are certainly very remarkable, considering that, strictly speaking, ice is neither viscous nor plastic. Chamberlin's explanation of movement as the result of granulation and a continuous adjustment of the granular structure to gravitative stresses through differential melting and regelation, obviates in a measure the difficulty of accounting for the complex movements observed; but the fact remains that relatively slight obstructions, whether of solid rock or uncompacted drift, are sufficient to originate sharp overthrust flexures and obliquely ascending shear-planes, which are marked by prominent bands of débris—ground moraine in process of absorption by the ice. To Chamberlin belongs the credit of observing and depicting, more clearly, perhaps, than any previous writer, the mechanism of the transfer of drift from a subglacial to an englacial position. There can be no doubt now that in a lee the ice, at least under certain conditions, will drag, in consequence of basal friction, sufficiently to give rise to a sharp flexure or a thrust fault between it and the ice which passes over the obstruction. A part of the latter is being constantly curved downward and backward and added to the stagnant ice; and thus the thickness of the latter increases with the distance from the lee slope; and the axial plane of the flexure rises to higher levels in the ice. Or, if the conditions of granulation, velocity, etc., determine shearing as well as or instead of flexing, the shearing plane will likewise tend to rise in the ice.

In an earlier publication,* Prof. Chamberlin has analyzed glacial motion and shown the importance, in a detailed study, of distinguishing vertical pressure, due to the thickness and weight of the ice, and flowage pressure, due to its horizontal movement. The former culminates in the basal central and the latter, as a rule, in the superficial peripheral tracts. These two pressures coöperate on stoss slopes, and hence glacial erosion reaches its maximum intensity there. Glacial striæ record, almost exclusively, the movements of the ice-sheet in its final stages; and it is well understood that the general absence of striæ on lee slopes above a certain low angle of declivity means that the flowage pressure then so far predomi-

*Seventh Ann. Report, U. S. Geol. Surv., 186-192.

nated over the vertical pressure that the ice tended to arch over the lee slope instead of flowing down it. Under the greater vertical pressure and lower velocity of the central areas the ice will hug the lee slopes more closely and they will be more generally glaciated. In this case, however, as truly as in the first, the ice in the lee must drag, that is, move more slowly than the ice above it; and this retardation will almost inevitably, according to Chamberlin's Greenland observations, lead to flexing or shearing and the absorption of detritus. We are thus brought to the conclusion that from the summit or crest of nearly every elevation with an abrupt lee slope a stream of detritus flowed onward and upward into the Pleistocene ice-sheet during its progress over the land. And it is obvious that, if this view be even measurably sound, the mechanism is provided for the abundant transfer of drift from a subglacial to an englacial position. This important conclusion may be presented in another way. The detritus urged up, or worn from, the stoss slopes by the movement of the ice clearly did not descend the lee slopes under the pressure of the ice, else these slopes would not be unglaciated; therefore it must have passed on into the ice, or else have accumulated in a passive form on the lee slopes. It was probably disposed of in both these ways; but it is well known that stoss slopes are quite as likely as lee slopes to be encumbered by ground moraine.

The recently published experiments in ice motion made with wax by E. C. Case,* have a special interest in this connection. They tally very closely with Chamberlin's Greenland observations, and materially strengthen our general conclusion that the forward motion of the ice over an uneven topography gives rise to obliquely ascending currents, and that from the summits of elevations basal detritus is carried, not down the lee slopes but forward and upward into the body of the ice.

It must, however, be conceded by the englacialist that during the period of maximum glaciation for any area, when the ice was thickest and the vertical pressure had its maximum value, a large proportion of the drift reaching the top of stoss slopes probably remained in the bottom of the ice and was

*Journal of Geology, III, 918-934.

dragged down the lee slopes and away from the elevations without losing its subglacial position. This must have involved the striation and polishing of the lee slopes, and the conditions were unfavorable for the detachment of blocks of rock—the rending and quarrying operations of the ice-sheet. Later, when the vertical pressure was less and the velocity of flow greater, the ice hugged the lee slopes less closely and the conditions became favorable for the detachment of blocks by the ice moving under the combined vertical and flowage pressure across the crests of the elevations. If the ice actually pulled away from the lee slopes to an appreciable extent, or even tended to do so, the local relief of pressure may, perhaps, have led to the freezing on these slopes of subglacial water. This sedentary ice, penetrating the joint-cracks of the rocks and by its expansive power starting the joint-blocks from their positions, and later, by its continued growth, becoming continuous with the moving ice, may have assisted in plucking away blocks and fragments of rock from the lower as well as the upper portions of the lee slopes, thus tending to maintain the high angle of declivity so characteristic of lee slopes.

The broken and precipitous character of typical lee slopes is, to my mind, rather inconsistent with the passage down them, during the detachment and removal of the blocks, of much ground moraine; and this conclusion is in harmony with the facts that they are not now, as a rule, banked high with till, and that we often find a surface train of angular blocks leading away from them. That the blocks thus borne away from a lee slope were, in many cases, carried in the ice instead of being dragged along beneath it is proved by the occurrence of entirely angular and unglaciated forms, and the fact that, as in the case of the great Madison boulder in New Hampshire, the original orientation of the blocks is sometimes unchanged.*

In the preceding paragraph I have but followed in the footsteps of Prof. Chamberlin, for he has shown† very fully and clearly that the ice flowing over and around prominent ledges and rocky hills will naturally carry away in true englacial fashion many angular blocks and more or less of other forms

*Appalachia, VI, 66.
†Journal of Geology, I, 47-60, and 255-267.

of detritus; and also that this, as he supposes, scanty englacial drift is now distinguishable from the ground moraine on which it rests. Having granted this much, Prof. Chamberlin is, apparently, obliged to ground his argument for the essential scantiness of the englacial drift upon the assumption, nowhere explicitly stated, that but little drift was dragged or carried by the ice up the stoss slopes and over the crests of the ledges and hills, for this material would obviously have an equal or better chance than that worn from these elevations of becoming truly englacial. But the validity of this tacit assumption cannot be admitted. The severe glaciation of the stoss slopes is against it; and, aside from this consideration, it is difficult to understand how, except in valleys trending with the glacial movement, any considerable amount of detritus that was transported or dragged a good fraction of a mile or more from its source could help crossing one or more elevations. Certainly its course would need to be very devious to avoid them.

Again, Prof. Chamberlin* has given us the important principle that, during the closing stages of the Ice age at least, the surface of the ice-sheet must have been depressed over highlands and elevated over valleys, and that, movement being determined by surface gradient alone, the ice would flow toward rather than from the highlands. This principle would thus operate to increase the ground moraine on the hilly tracts at the expense of that in the valleys and lowlands; and it has occurred to me that perhaps we have here an explanation of the long ridge-like accumulations of till which often, on the plain country, border or separate the north-south valleys. Just as a river does not make its chief deposits in the deepest part of its channel, where the current is strongest, but along the margin, building up the flood-plain, so the ice-stream tends to crowd the detritus out of north-south valleys, from the line of swiftest to the lines of slowest motion. From these till ridges we pass easily and naturally to drumlins. Every glacialist knows that the drumloid slopes of till, which may, in my opinion, be regarded as embryo drumlins, although most characteristic of stoss slopes, occur abundantly on lee

*Seventh Ann. Report U. S. Geol. Sur., 184, 185.

slopes also. They seem to indicate an attempt on the part of the ice-sheet to carry or drag a large amount of drift up the stoss slopes. When the drift gains the crest, it is in part carried away into the body of the ice by the freer motion of the ice above this level, tending to leave the lee slopes bare, as already noted. But during the waning of the ice-sheet its movement over the rock hills and ledges finally became so feeble that it could no longer urge all the subglacial drift, the amount of which was probably being augmented by basal melting, up the stoss slopes, and it began to accumulate upon them. Each increment was so thoroughly compacted and pressed down by the ice, aided by the natural tenacity of the clay, that the effective stoss slope was gradually raised, until the accumulation of till finally over-topped the rocky obstruction and became a drumlin. This view seems to be in entire accord with Prof. Chamberlin's recent suggestion with regard to the origin of drumlins.*

Perhaps the general conclusions to which my studies have now led me may be best stated as follows: A large part, probably the main part, of the preglacial surface detritus was englacial in the sedentary ice-sheet and remained so after the ice began to flow during the entire period of the growth, culmination, and early decline of the ice-sheet, or while the hard bed-rock surface was being actively abraded and striated. During this time, which embraced the greater part of the Glacial period, the preglacial detritus not originally incorporated in the ice and the material worn from the ledges by the ice itself became englacial, in large parts at least, through overriding, shearing, and flexing movements of the ice, a hard surface of drift-shod ice in direct contact with the uneven bed-rock surface appearing to be essential to the rectilinear striation of the latter. During the later stages of the decline of the ice-sheet, basal melting set free considerable volumes of the hitherto englacial drift to form the ground moraine; and just as the frontal or terminal moraine, also composed of material set free by the ablation of the ice, records the cessation of the forward movement or invasion of the ice-sheet, so the basal or ground moraine records the gradual cessation of the glacial abrasion of the bed-rocks. The relative sud-

*Journal of Geology, III, 480.

denness of this change from active erosion to deposition in any area is indicated by the fact that, generally speaking, the ground moraine rests everywhere upon normally striated surfaces. In other words, as soon as the ground moraine began to appear through basal melting it was essentially motionless; for ice moving over a bed of detritus in a way to impart motion to it would inevitably give rise to sidewise, oblique, and devious movements of individual stones which would tend to obscure and efface the rectilinear striation of the bed-rock surface. The ground moraine as it accumulated was pressed down by the ice to form the typical hardpan. In part it accumulated on stoss slopes through obstruction to, and in part on lee slopes through protection from, the forward movement of the ice, forming drumloid slopes and, later, drumlins.

It is not a necessary deduction from this view that the bed-rock always rises to a good hight in drumlins, since the hardpan character of the ground moraine and the tendency of the ice at this stage to flow over loose materials, as observed by Niles, Spencer, Chamberlin, and many others, makes of the initial knob or boss of the ground moraine an efficient gathering point for more material as fast as it is furnished by the melting of the ice. The main point may be presented in another way. When, as in the earlier and maximum stages of the ice-sheet, the basal temperature was below freezing, the freezing of subglacial waters made and kept the detritus a part of the ice-sheet; and when, as in the later stages of the ice-sheet, the basal temperature rose above freezing, the ice relaxed its hold on the detritus and flowed over it, as attested by observations on modern glaciers.

It is a necessary consequence or corollary of this view that transportation of drift by simple drag is relatively unimportant, if not impossible. The transportation is almost wholly englacial, as insisted by Upham,* but highly differential, being extremely slow in the basal layers and more and more rapid at higher levels. The detritus reaching the highest levels in the ice is carried farthest, not only because of the higher velocity, but also because it remains for a longer time in the ice.

*Bull. Geol. Soc. Amer., VI, 348.

The history of an ice-sheet embraces, as regards the basal temperature, two distinct and contrasted periods: (1) the period of growth and maximum development, when the temperature of the lower part of the ice is permanently below freezing; (2) the period of decline, when the basal temperature is above freezing. The first is the period of active abrasion and scoring of the bed-rock, all detritus being frozen into the ice as fast as formed. Furthermore, the water resulting from superficial summer melting of the ice, descending through crevasses to the basal portion of the sheet and refreezing there, not only adds the newly formed detritus to the base of the moving sheet, but also, perhaps, favors an actual downward growth of the ice-sheet, whereby detritus which has previously become englacial is raised to greater hights in the ice, the growth of the ice-sheet being chiefly upward by snowfall in winter and downward by basal freezing in summer. During the second period the ice-sheet wastes by basal as well as superficial melting, the englacial drift becomes subglacial (ground moraine) and glacial erosion gradually ceases.

The prevailing opinion among geologists, as recently collated by Culver,* is evidently strongly against the efficiency of glacial erosion; and this trend of opinion is certainly justified, so far as it is based upon observations on living glaciers. Observations on the velocity and abrasive power of modern ice-sheets have never been made. But the relatively high efficiency of the Pleistocene ice-sheet in this respect is clearly proved by the undisputed facts that, over practically the entire glaciated area north of the terminal moraine, *all* the preglacial sedentary soil and partially decayed rock was worn away, involving on a large aggregate area extensive erosion of the hard unaltered rocks; and that the prevailing color of the ground moraine, below the sharply defined limit of postglacial oxidation, is that of crushed rock and not of residuary or other preglacial detritus. The latter fact, which seems to have been but little regarded, is probably of equal significance with the first; and the general conclusion based upon both these is further sustained by observations upon the proportions of distinctively glacial detritus in the ground moraine.†

*Trans. Wis. Acad. Sci., etc., x, 339-366.

†Proc. Boston Society of Natural History, xxv, 131-138.

It is a logical deduction from the view developed here that there can exist in the ground moraine, in general, no real or definite distinction between subglacial and englacial till, because, broadly speaking, it has all been englacial.

Probably no feature of the Greenland glaciers revealed to us by Chamberlin's studies will be regarded by glacialists with greater interest and astonishment than the beautiful stratification and lamination of the ice. He states, and his photographic illustrations show, that the stratification is most perfect in the lower, drift-laden portion of the ice, being only obscurely seen in the upper white ice. It is especially interesting to note in this connection that in the drift-laden ice the stratification is due chiefly to the mode of distribution of the drift or rock débris, which forms numerous relatively thin and continuous layers approximately parallel with the bottom of the glacier and often exhibiting flexures and faults where the ground over which the glacier moves is sufficiently uneven. Chamberlin refers all this englacial drift to one source. It is ground moraine which has been absorbed by the ice through flexing and shearing movements; and it proves that this process of absorption is essentially continuous. The thinness and persistence of the layers of débris also prove that the planes of shearing extend forward indefinitely into the body of the ice, and do not tend to die out, as they would if the ice were a viscous or plastic substance. This differential movement along an inset layer of débris must drag it out and tend to give it persistence, even if the process of absorption in that plane is intermittent.

Furthermore, we find here a most striking confirmation of the conclusion previously stated, that, under certain conditions at least, the débris in the ice is an element of weakness and tends to give rise to shearing and gliding planes. This whole process of lamination by shearing is beautifully attested by the marked projection of the upper layers on the precipitous margin of the ice due to ablation. The under surfaces of the projecting layers are fluted by the fragments of rock lying in the plane of shearing. But in spite of this indication that the ice moves over the enclosed detritus, it is obvious that the movement must also drag it along; and when we consider how intimate this process of lamination shearing is, producing in extreme cases as many as twenty distinct layers in an inch, it can hardly be doubted that the englacial rock fragments, more especially if of small size, must suffer facetting and striation after the manner of the ground moraine. Thus one supposed distinction between subglacial and englacial drift in a measure disappears and is no longer available as an argument to minimize the englacial drift of the Pleistocene ice-sheet.

Professor Chamberlin has noted* that while the Greenland glaciers commonly slide over the ground moraine in their lower courses, allowing it to accumulate beneath them, they appear in their upper courses to drag and carry it along, fitting snugly in their respective valleys and scoring the ledges over which they move. By parity of reasoning we may suppose that, although at its lower extremity the ice is observed to slide over the interstratified débris, farther back from the margin the débris, being frozen in the ice, is urged along and glaciated by the motion of the ice.

I have observed something analogous to this lamination shearing of glacial ice in the obsidian flows of the Lipari islands. In consequence, perhaps, of incipient crystallization, or of partial relief from pressure, due to the fact that the lava continued to flow after it had begun to stiffen, imprisoned or dissolved aqueous vapor is liberated along certain planes coincident with the plane of flowing, giving rise to layers of vesicles. These vesicular layers (analogous to débris layers in the glacier) become, with continued stiffening of the magma, relatively planes of weakness and hence shear planes, —a true flowing movement which affects the entire body of magma being transformed in part, by continued pressure from behind, to mechanical shearing along definite planes.

COMPARISON WITH MODERN GLACIERS AND ICE-SHEETS.

Perhaps the most cogent argument against the view that the drift of the Pleistocene ice-sheet was, during certain prolonged phases of its history, largely or chiefly englacial, is that based upon the comparative rarity of englacial drift in modern glaciers, and, seemingly, in modern ice-sheets. The general freedom of glaciers of the alpine type from incorpo-

*Journal of Geology, III, 67, and 208-210.

rated drift, other than that derived from lateral and medial moraines through the agency of crevasses, is, no doubt attributable to the facts that their courses were long since swept relatively bare of detritus, and that in their lower courses they are undergoing basal melting and hence depositing rather than absorbing drift.

According to the observations of Chamberlin and Salisbury* the numerous glaciers descending from the margin of the Greenland ice-cap present, in this respect, two types: (1) the drift-laden glaciers, which have commonly vertical sides and ends, and predominate north of lat. 76°; (2) the apparently drift-free glaciers, which are commonly without prominent vertical sides or ends, and predominate south of lat. 76°. Both these able observers state emphatically that in the drift-laden glaciers the drift is strictly a basal feature, rarely rising to greater hights in the ice than 100 to 150 feet, even where the glacier may be a thousand feet or more in thickness. Furthermore, these observations are regarded as fully confirmed by those made upon the countless icebergs of the neighboring seas. We may, perhaps, reasonably suppose that the greater abruptness of the northern glaciers is due in some measure to the more rapid melting of the drift-laden basal layers of the ice, in consequence, as already explained, of the low specific heat of the imbedded débris; and that, possibly, the northern glaciers are more generally drift-laden because the severe climate tends to prevent basal melting. Certain it is that the englacial drift is, in general, most in evidence where the basal conditions most closely approximate those of an ice-sheet in its prime.

It appears to me, however, extremely improbable that all the englacial drift of the Greenland glaciers has been absorbed by the ice during its comparatively short and steep descent from the margin of the ice-cap. I would suggest instead that a considerable part of it represents the lower drift-laden portion of the ice-cap itself. Whether these lobes of the ice-cap are well charged with drift or not is of no special significance in a study of the Pleistocene ice-sheet of North America, unless we can regard them as reliable indications in this respect of the constitution of the parent ice-cap. Assuming with

*Journal of Geology, III, 875-902.

Chamberlin that, while the upper clear ice of the Greenland glaciers increases rapidly in thickness from the lower end upward toward the ice-cap, the basal drift-laden ice increases but little if any in thickness, is it a necessary conclusion that in the ice-cap itself, thousands of feet in thickness, the englacial drift is limited to the lower 100 to 200 feet? To answer in the affirmative is to lose sight of the principle that the velocity of the ice increases rapidly upward from the bottom. The ice-cap virtually spills over the edge of the plateau through deep V-shaped notches; and to my mind the conclusion is unavoidable that a much larger proportion of the upper, clear and relatively mobile ice will flow down than of the lower, drift-laden, and relatively immobile ice. It is probable that increased declivity would in any case accelerate the velocity of the upper more than of the lower layers of ice; but this contrast would certainly be greatly intensified by the section of the valley—broad and open above and narrow below.

It is the general belief of geologists that, if Greenland were divested of its ice-cap, it would exhibit continental relief—elevated margins and a depressed interior. Hence we may assume that the ice-cap attains its maximum thickness in the central areas, and that a smothered mountain range separates this main body of ice from the overflow fringe of glaciers along the coast. The futility of regarding these smaller coastal glaciers as representative, in the matter of englacial drift, of the great ice-cap from the marginal and superficial portions of which they originate, is obvious.

The Humboldt glacier, and others of the great glaciers of the Greenland coast, belong in quite a different category, occupying as they do, apparently, the lower courses and mouths of the great interior valleys. But terminating in the sea, we can only judge of their basal conditions by the icebergs to which they give rise. It is, perhaps, fair to assume that, through basal melting, these giant glaciers, like their smaller brothers which fail to reach the sea, are building platforms of the ground moraine beneath their extremities, and thus permanently shallowing or filling up the bays along the coast. But that the icebergs often carry away generous loads of drift is well known; and we may specially note, in this connection, (1) that perhaps many of what pass for small bergs are really large bergs deeply laden; (2) that bergs well ballasted with drift cannot possibly be overturned so as to expose the drift to observation: and (3) that the drift-bearing part of a berg, under the combined influence of the higher specific heat of rocky débris and gravitation, must melt away very rapidly when the temperature of the water is above freezing. Again, these giant glaciers are simply ice rivers draining at lower levels the great *mer de glace* or interior sea of ice; and, just as in the case of the water of a lake and its outlet stream, the velocity of the ice must be greatly accelerated in passing from the *mer de glace* to the glacier. From this premise the conclusion follows irresistibly, as previously noted, that the glacier will consist in much larger proportion than the *mer de glace* of the upper drift-free ice. Hence we can hardly suppose that even a clearly exposed section of the Humboldt glacier would reveal to us a true and undistorted vertical section of the Greenland ice-cap, for the basal layers certainly would not be adequately represented. Thus observation is baffled at every point, unless, indeed, a boring should some time be made in the interior of Greenland. I see no reason, however, to doubt that the *mer de glace* is well supplied with englacial drift, or that wherever the ice is actively abrading its bed it holds in its mass the entire volume of detritus, moving, full armed and without any intervening shield or ground moraine, over the unprotected bed-rock.

That the englacial drift rises to a great proportional hight in the Greenland or any other ice-cap appears to me, however, by no means a necessary conclusion. Probably very little rises to a greater hight than 500 feet, or possibly 1,000 feet, even where the thickness of the ice is one to two miles. In fact, none of the suggested processes of absorption seem competent to diffuse the detritus through any considerable thickness of the ice, or to carry it far above the summits of the obstructions which give rise to the shearing and flexing movement. I conceive it, rather, to be somewhat crowded in the slow-moving basal strata of ice, whence it is early set free by basal melting to form the ground moraine, and to thin out rapidly upward. Among the causes tending especially to check or limit the upward movement of drift in the ice is the progressive increase in the velocity of the ice from the base upward, in obedience to the principle, already noted, that a current tends to force floating bodies from the lines of highest velocity to those of lowest velocity.

It is possible, however, that, as virtually pointed out by Upham,* an important exception to this limitation of the range of englacial drift should be made for the case when a later sedentary ice-sheet is overriden by the readvance of an earlier sheet, the hight attained by the englacial drift depending then upon the thickness of the overridden sheet. Again, a mountainous tract lying in the pathway of the ice-sheet may lead to the incorporation of drift at exceptionally high levels. In fact, the Malaspina glacier is a capital example. According to Russell, the drift which mantles the outer margin of this great piedmont glacier, covers, even in parts of the area where it is forest-clad, not less than a thousand feet in thickness of ice; and where it is not forest-clad it rises to still greater hights. Russell states that this superglacial drift consists wholly of the lateral and medial moraines of the tributary glaciers descending from the Mount St. Elias range.

All of the glaciers which feed the great Piedmont ice-sheet are above the snow line, and the débris they carry only appears at the surface after the ice descends to the region where the annual waste is in excess of the annual supply. The stones and dirt previously contained in the glacier are then concentrated at the surface owing to the melting of the ice. This is the history of all the moraines on the glacier. They are formed of the débris brought out of the mountains by the tributary Alpine glaciers, and concentrated at the surface by reason of the melting of the ice.

Probably this incorporation of drift at high levels would still occur, but on a grander scale, if the St. Elias range were completely buried in ice moving across it. Regarding these St. Elias glaciers as rivers of ice tributary to a sea of ice, the thought is naturally suggested that perhaps the drift-laden ice tends, on joining the piedmont glacier, to flow out across the ice sea regardless of its depth, and thus, while actually descending topographically, rise to greater hights in the ice-sheet. This principle would also, obviously, find application in the case of valleys or depressed areas of any form, transverse to the general direction of flow of the ice-sheet; and it

*Bull. Geol. Soc. Amer., VII, 21, 22.

thus becomes simply a broader phase of the principle of the absorption of detritus by shearing and flexing. These considerations lead me to venture the opinion that, while depths of englacial drift amounting to 1,500 or 2,000 feet or more, or to one-fourth to one-third of the thickness of the ice-sheet at its maximum, as held by Upham, cannot be regarded as strictly normal or as prevailing over considerable areas of plain country, they are possible under the special conditions indicated.

Relations of Englacial Drift to Modified Drift.

The manifold forms of modified drift, or washed and stratified gravels, sands and clays, of glacial origin, forming deltas, terraces, overwash or apron plains, eskers, kames, etc., although occurring almost wholly in valleys and on lowlands, constitute in the aggregate a considerable fraction of the total volume of the drift. Concerning the source of the modified drift, there is as yet no general agreement among glacialists. The main views, of which all others may be regarded as modifications, are: (1) that the modified drift has resulted chiefly from the washing and assorting of the till or ground moraine by glacial streams, during and following the waning and disappearance of the ice-sheet; (2) that it was derived from englacial drift through the agency of subglacial streams; and (3) that it had its origin in englacial drift which became superglacial by ablation and was washed and assorted by superglacial streams. Undoubtedly all of these theories are required to account for the totality of the modified drift; and the real question is as to their relative importance.

It is inconceivable that the ice-sheet could disappear without some washing or modification of the ground moraine. It is, however, a noteworthy fact that the till does not present about the heads of southward sloping valleys or elsewhere evidences of such extensive erosion as should be required for the general or unqualified acceptance of this view. The absence, as a rule, of strongly marked erosion lines in the ground moraine is particularly striking in the case of the drumlins, since their highly definite and characteristic contours due to glacial moulding make them extremely delicate records of aqueous erosion. Every glacialist knows how rare and insignificant are the evidences of drumlin erosion which can be referred to subglacial streams. Superglacial and marginal streams have here and there notched the summits or terraced the sides of protruding drumlins: and frost and rain-wash doubtless accomplished some degradation of the drumlins after the disappearance of the ice and before the mat of vegetation was spread over them. But when all these modes of erosion are taken into account, the waste which drumlins have suffered still appears so trifling that, if they were regarded as representative in this respect of the ground moraine in general, all subglacial material might, perhaps, be safely neglected as a source of modified drift. In fact, the advocates of the derivation of the modified drift from the ground moraine should, it would seem, also espouse the theory that drumlins are mere erosion-remnants of a sheet of till of much greater average thickness than that which now encumbers the glaciated area.

It may be noted, however, that, as I have elsewhere pointed out,* the ice-sheet was probably accompanied, at least in its later stages, by a more or less complete system of subglacial drainage; and during all the time while the ground moraine or subglacial till was accumulating through basal melting, and also while it was still englacial, through the agency of numberless shearing planes, it was undergoing modification by the washing out of its finer constituents, clay and rock-flour. Obviously, of this differential erosion no distinct trace or scar could be expected to survive the disappearance of the ice-sheet, especially since the action could not have been sharply localized, but must have affected in some degree almost the entire area of the ground moraine.

While not denying or doubting that the ground moraine has made, in various ways, substantial contributions to the modified drift, I recognize that the relations of the still englacial drift to glacial drainage afford a more direct and satisfactory explanation of the main part of the modified drift.

The real problem appears, then, to be as to the relative efficiency of subglacial and superglacial streams. Upham, the foremost advocate of the efficiency and sufficiency of

*Proc. Boston Society of Natural History, xxv, 117.

superglacial streams, holds that the englacial drift became superglacial, by surface ablation of the ice, in sufficient volume to account for practically all the various types of modified drift, and that the superglacial streams were adequate for its transportation and deposition. That this must be the history of a part of the modified drift is obvious from the fact that these conditions are realized in modern ice-sheets; but they are only realized, it must be added, to a very limited extent.

It is a common and, perhaps, a fair assumption that in Greenland and Alaska are exhibited now, on a smaller scale, nearly all the essential phases of the disappearance of the Pleistocene ice-sheet. A general survey of these and other regions now undergoing glaciation has revealed only one notable occurrence of superglacial drift, namely, that mantling the outer margin of the Malaspina glacier; and that, as we have noted, is of somewhat exceptional origin, inasmuch as it is not derived from strictly normal englacial drift. Little more can be said for superglacial streams. They are either entirely wanting, or they are short-lived, being almost invariably swallowed up by crevasses and rarely discharging over the margins of the ice-sheets. Nowhere, so far as I am aware have superglacial streams been observed actively washing and distributing superglacial drift. Assuming, as I think we must, that the englacial drift is crowded in the basal layers of the ice, enormous wastage of the ice must occur before it becomes superglacial; and the extreme brittleness and consequent fissuring of the ice protects it from the ravages of superglacial streams, until in the course of time it becomes forest-clad and assumes the character of an ancient soil.

It seems to me very probable, however, that when considerable sections or areas of the Pleistocene ice-sheet were so far wasted as to be absolutely stagnant, and when superglacial drift covered its surface and checked the melting of the ice, the still existing crevasses may have become choked with drift to such an extent as to keep the streams superglacial or in channels open to the sky, and thus to realize the essential conditions of the formation of modified drift from superglacial drift. Meanwhile, however, or before these conditions are realized, the water resulting from the melting of thousands of feet of ice has escaped from the ice-sheet through subglacial channels; and during its entire subglacial course the main body of the englacial drift has been within its reach and undergoing modification. This consideration, and the contemplation of the deposits being made at the present time by the Fountain stream, the Yahtse, and other rivers emerging from the base of the Malaspina glacier, not to multiply examples, satisfy me that not only is the modified drift, so far as it is being formed at the present time, the product chiefly of subglacial streams acting on englacial drift, but that it probably was so in Pleistocene times. When it is generally recognized that the modified drift requires not one but several theories, criteria will, doubtless, be established by which we may determine for any normal example whether it has been derived chiefly from subglacial, englacial, or superglacial drift.

THE TRANSPORTATION ARGUMENT.

Notwithstanding the abundant and indubitable evidence that a small part of the drift of the Pleistocene ice-sheet is far-travelled, it is generally conceded that the great bulk of the drift is of relatively local origin; and good authorities hold that this is substantially true for the modified drift as well as till. My own studies in the Boston basin have satisfied me, however, that the modified drift and till of this region are somewhat contrasted in this respect, though perhaps not more than we should expect, considering that the modified drift was transported by water as well as by ice. For example, with the aid of several students in the Massachusetts Institute of Technology, I examined the composition of a prominent esker on the northwest shore of Weymouth. North of this point in the line of glacial movement are three broad belts of rocks: first, slates and conglomerates of the Boston basin (Carboniferous), about thirteen miles; second, hornblendic granites, diorite and felsite, with some Cambrian slate and quartzite, eight to ten miles; third, mica schists, muscovite granites and gneiss, pegmatite, etc., extending into New Hampshire. We found, on looking over some tons of material, that of all which was coarse enough for easy identification about 50 per cent. is from the first belt, 40 per cent. from the second, and 10 per cent. from the third. Subsequently at points only two to five miles from the northern edge of the Boston basin, I found the proportion of material from the first belt in the modified drift very small, 10 per cent. or less. Hence it is probably safe to assume that more than half of the coarser material of the modified drift of the Boston basin is five to ten miles from its source, and a good fraction as much as twenty miles.

But conceding that the readily identifiable constituents of the drift, whether modified or unmodified, are chiefly of distinctly local origin, it may still be doubted whether much weight should be attached to this fact as an argument against the view that practically the entire volume of the drift was englacial in the earlier and maximum stages of the ice-sheet. For the purpose of this discussion, the drift may be divided into three parts: first, the preglacial detritus, which must have been chiefly of a residuary and clayey character and highly oxidized (red and yellow), like the residuary soils of the South; second, the finer products of glacial erosion, rock flour, etc., formed chiefly on stoss slopes and for the most part unoxidized; third, the coarser part of the drift, the identifiable rock fragments, which must be almost wholly of glacial origin and derived chiefly from the lee slopes.

The preglacial residuary and sedentary soil was probably partly swept away by aqueous erosion during the elevation of the continent and before the formation of the ice-sheet. What was left of it probably became incorporated with the ice-sheet in its earliest stage; and we may well suppose that during the various vicissitudes of the ice-sheet, and through the coöperation or alternation of glacial, lacustrine and fluvial transportation, it has been carried in large part beyond the limits of the glaciated area. Certainly there is little indication of its presence in the composition of the drift; and experiment shows that an admixture of a very small proportion of highly oxidized residuary clay, like that of the South, with a typical till is readily detected in the change of color. It is a natural suggestion, therefore, that the Lafayette and Columbia formations of the South have been derived, along their northern borders, in part from the preglacial residuary soils of the North. The finely comminuted and unoxidized glacial detritus constitutes now the basis or matrix of the till and is very largely represented in the modified drift. But except to a very limited extent it is entirely unidentifiable as to its source and the distance of its transportation. The vast deposits of modified drift in southeastern New England, and the great average thickness of till in Ohio and other interior states, not to mention distinctly morainal accumulations, indicate, however, when compared with the scanty deposits of drift over many northern areas, in New England and Canada, that a large volume of the older, finer, and less readily identifiable part of the drift is relatively far-travelled. In its earliest stages the ice-sheet, we may reasonably suppose, wore away and absorbed a considerable thickness of rotten rock underlying the residuary soil; and during its maximum stage, as already noted, the hard rocks suffered glacial abrasion on the lee slopes as well as on the stoss slopes. The conditions must then have been very unfavorable to the rending of the ledges and the detachment of fragments and boulders: but this came later, with the decline of the ice-sheet, when the flowage pressure so far predominated over the vertical pressure that the ice pulled away from, instead of following down, the lee slopes.

Approaching the subject in this way, I can see no escape from the conclusion that the rock fragments and boulders must date chiefly from the later stages of the ice-sheet. Hence they must have been, in general, the last material to be absorbed by the ice-sheet and the first to be deposited by basal melting. Under favorable conditions of flexing or shearing a small part of this material attained a high level in the ice and enjoyed a long glacial transport; but the fact that most of it is still near the parent ledges will, I judge, be found quite consistent with the englacial theory, if due allowance be made for the relatively short time that it was enclosed in the ice, and for its basal position and the low velocity of the basal layers of the ice. Although the total forward movement of the ice, as indicated by far-travelled erratics, appears to have been as much as five or six hundred miles, and even in some parts of the glaciated areas perhaps a thousand miles, a basal slipping of one-twentieth of that distance or less would probably be regarded as sufficient to account for the erosion of the bed-rock surface and the normal distribution of the identifiable fragments. In this connection, I venture to repeat the suggestion that possibly the total movement of the ice has been over estimated, the more distant erratics having been, perhaps, transported in part by water and not wholly by the ice-sheet, each marked recession of the ice-sheet providing a series of glacial lakes and rivers along its margin.

Since writing out this paper, I have realized more distinctly than before that the points relating to the entire volume of the drift having been englacial during the active erosion of the bed-rock, the efficient protection afforded glaciated surfaces by even a thin layer of till, and the consequent ruling out of drag as a mode of glacial transportation, have been previously stated by Mr. Upham.* But since I have approached the subject in quite a different way, and there are still minor points of difference, this general acknowledgement is, perhaps, preferable to any attempt at quotation.

FURTHER EXAMINATION OF THE FISHER METEORITE.

By N. H. Winchell, Minneapolis, Minn.

From a coarsely powdered portion of this meteorite all grains were extracted which would adhere to a small magnet. This process removed also an equal bulk of other minerals which adhered to the metallic iron by reason of its interlocking contacts.

The rest of the powder was placed in iodide of methyl having a specific gravity of 2.776, causing a separation into two portions. The heavier portion contained the residue of the iron, with still some interlocking grains, the troilite, olivine and the enstatite, and the lighter contained grains which could be divided into six groups.

1. Some white, composite grains, though apparently homogeneous in composition, which gave by a Boricky test abundant microlites of magnesia, or of lime and magnesia; a biaxial mineral.

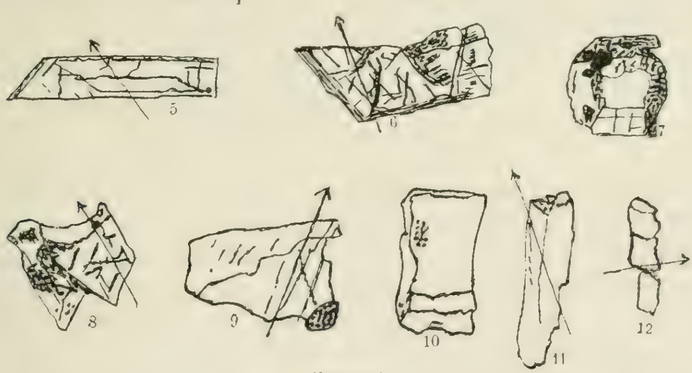
2. Isotropic, but wholly transparent, grains holding many inclusions which render them sometimes almost opaque, or which polarize independently. These must be taken for glass. Some are black, derived probably from the crust, of which a small

*Bull. Geol. Soc. Amer., v, 71-86, etc.

portion was included in the fragment which furnished the powder. Four of these are represented below by the figures Nos. 1 to 4. They are constantly dark between crossed nicols, except where the small inclusions lie. In fig. 4 at *aa* are brightly polarizing crystallites. This isotrope is less refractive than the doubly refracting light mineral as well as than the enstatite and olivine.

GROUP 2.

3. A glassy-clear mineral, usually free from inclusions but not wholly, having cleavage in five directions. Several of these are represented by the figures below. Figures 5 and 6 are the most useful, as they not only show the cleavages but also a facial angle of 120°, belonging to a hexagonal prism. They each measure a little more than 120°, but as the grains are a little inclined upon the vertical axis this excess over

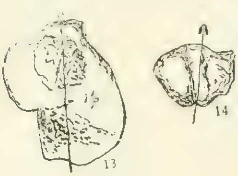


GROUP 3.

120° can be neglected. Fig. 5 has this angle 126 degrees and fig. 6 127°. The interference figure in No. 6 is simply an arm of the black cross, like that of No. 5, but more evident. In fig. 7, which is very thick, there are visible two cleavages, and the interference figure is indistinct. In fig. 8 the central part polarizes in colors, but in general it is white. The interference figure is a branch of a black cross. In asmanite n_p (a) is perpendicular to the easy cleavage and in tridymite from

La Capucin *ng* (c) is perpendicular to the "hexagonal" base. This grain is quite similar in all characters to Nos. 5 and 6. No. 9 has a large inclusion which adheres to one corner. Its interference figure is also a branch of a black cross. In No. 10 the same part of the interference figure is visible in convergent light. Its colors show two orders of red. Figs. 11 and 12 resemble each other in their manner between crossed nicols, but as No. 11 shows an axis of elasticity of which the index is *np* (a) and reveals a very small measure for 2E, it may be allied to the group No. 4. They both polarize in low tints of the first order. These grains all have a strongly conchoidal fracture. They are not soluble in hydrofluosilicic acid.

4. A mineral which shows no evident cleavage, has a rusty yellowish yet clear transparency when free from inclusions, in form roundish-angular, polarizing in the tints of the first order even when rather thick. Represented by the following figures (13 and 14). The grain represented by fig. 13 lies so as to show the axis *np* vertical; the arrow shows the direction of the axial plane. The optic axial angle is very small. It may be estimated at 10° to 15°. In the grain figured this axis seen in the upper half is not parallel with the same seen in the lower half, indicating the existence of a twinned individual. Fig. 14 shows white polarization tints of the first order. The central portion of fig. No. 13 shows a yellow color, but in parallel light it is rather obscure throughout. Fig. 14 seems also to lie so as to show an elasticity axis, but the grain is so thick that it cannot be identified with certainty. It is possible that fig. 11 should be removed to this group.



Group 4.

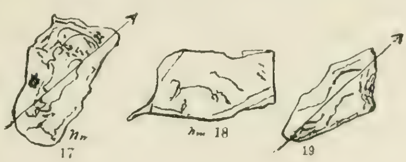
5. Water-clear grains with sharp or conchoidal fracture, which have not disclosed any cleavages. On an oblique surface fig. 15 transmits light between crossed nicols, but otherwise it is wholly isotropic. The whole central portion (a) remains dark, while the edges (b) which are obliquely fractured, transmit light, and darken at four points in rotation, the arrow showing the direction of extinction. The two little grains shown in fig. 16 have no optical characters except that

of being isotropic and very refractive. They are drawn too large in comparison with the grain represented by fig. 15. They are really not more than one-fourth the size of that. These grains may all perhaps be placed in group 3, on the supposition that they happen to lie in a position showing an optic axis, but on that supposition they not only ought to afford an optic axis interference figure, but they would agree better with group 4, on account of the absence of cleavage.

15 16

GROUP 5.

6. Grains that polarize in colors show no evident cleavage, but a tendency to fracture in a sub-conchoidal manner with irregular planes of parting. Their relation to none of the foregoing is strong, but they might be placed in No. 3, or in No. 4. They are evidently from a mineral of strong character, but these grains do not show them favorably. Figs. 17 and 18 seem to show an interference figure in convergent light resembling the axis *nm* (b), the optic normal.*



17 18 19

GROUP 6.

In all the preparations are numerous other grains which are largely isotropic, but charged with inclusions, some of which are black and some partly translucent, so that a little light gets through the body of the grain. But when the inclusions are wanting, as about the edges of the fragments, these grains are clear and isotropic, like No. 4 above. These grains are therefore, more or less obscure and partly doubly refracting.

Careful reëxamination and comparison of all the characters expressed in these figures seem to indicate the presence of four distinct different minerals, viz.:

Group 1. Probably a loosely aggregated yet granular mass of olivine, rendered light by its porosity. Spots loosely sac-

*Nos. 5, 4, 13, 16, 17 and 18 are in preparation No. 1. Nos. 1, 12, 14 and 19 are in preparation No. 2. Nos. 6, 7, 11, 10, 3, 15, 9, 8, 2, 19, are from preparation No. 3.

charoidal can be seen on the cut surface of the specimen from which the thin sections were taken.

Group 2. Glass, with inclusions. This is quite abundant. In some cases in the mounted thin sections the little olivines seem to swim idiomorphically in this glass. In others it is crowded with hundreds of black octahedra whose nature is unknown.

Group 3 (and possibly groups 5 and 6). Asmanite (tridymite). By the kindness of Prof. A. Lacroix samples of the tridymite of the Breitenbach meteorite have been compared with the grains represented by this group. In conchoidal fracture surfaces, in cleavages and in double refraction the two are identical. They are equally similar to the tridymite of Rocher du Capucin.

Group 4. An unknown substance which has a bisectrix *np* (a) and an optic angle of 10° to 15°. The black cross hardly becomes distorted on rotation. The characters assigned to maskelynite by Tschermak do not apply to these grains very well in respect to their general outlines, nor in respect to their resemblance to plagioclase.* In making a Boricky test of the grains of the mixed powder those of group 3 remained undissolved. The only crystallites that were formed were biaxial and indicated lime, or lime and magnesia. No soda nor potash was found in the test made. In the absence of cleavage, only, does group No. 4 resemble maskelynite, while in the peculiar and only partial double refraction, group No. 5 resembles maskelynite as defined by Tschermak.

Paris, Jan., 1896.

[*To be continued.*]

EDITORIAL COMMENT.

Glacial Lakes of the St. Lawrence Basin.

Quite diverse opinions have been held concerning the nature of the bodies of water which formed the Late Glacial or Champlain shore lines in the St. Lawrence basin, ranging in hight, in different portions of the region, from a few feet up to more than 600 feet above the present great Laurentian

*The characters of maskelynite and of tridymite are summarily stated by Cohen in his recent work, *Meteoritenkunde*, Stuttgart, 1891.

lakes. Newberry, N. H. Winchell, Gilbert, Leverett, and the present writer, have referred these old beaches to glacial lakes, obstructed in the present direction of outlet by the barrier of the waning continental ice-sheet. Spencer and Taylor have regarded the higher and more important shore lines as probably of marine formation, believing that after the Glacial period the sea extended in great inland gulfs to lakes Michigan and Superior. Lawson, examining these beaches on the north side of lake Superior, concluded that there they are lacustrine, but due to dams of land rather than of ice. Those glacialists who have studied the records of lake Agassiz, the grandest example of these Late Glacial lakes, of lake Newberry and many others in the region of the Finger lakes in western and central New York, of lake Passaic in New Jersey, of lake Contoocook in New Hampshire, and of lakes Bouvé, Charles-Neponset, and Shawmut in eastern Massachusetts, all of which seem to be clearly referable to the barrier of the continental glacier during its final retreat, will gladly approve the letter of Mr. F. B. Taylor, given in our present number, in which, after a thorough study of these old shore lines about the upper Laurentian lakes and search for their continuation east of lake Nipissing, he declares his conversion, with little doubt remaining, to the doctrine that all these shores were formed by ice-dammed lakes.

Mr. Taylor further states in this letter that he cannot accept the opinion of Spencer, Lawson, and the present writer, that lake Warren (or, as Spencer might call it, the Warren gulf) extended over the present four lakes, Superior, Michigan, Huron, and Erie. Instead, according to Mr. Taylor's view, based on his exploration and correlation of the old beaches and deltas, lake Warren, so named by Spencer from his careful survey of the beaches adjacent to lake Erie and the southern part of lake Huron, had indeed no farther extent, never including the area of lakes Michigan and Superior, but overflowing to the glacial lake Michigan by the Pewamo channel, southwest of Saginaw bay, which has been recently described by Mr. E. H. Mudge.*

*Am. Jour. Sci., III, vol. L, pp. 442-445, Dec., 1895. Compare also Mr. Mudge's papers in the Am. Geologist for Nov., 1893, and Nov., 1894.

Probably the view presented by Mr. Taylor is true for the early stage of lake Warren when it was forming the Belmore, Ridgeway, or Sheridan beach in the Erie basin; and this Pewamo lake may be accepted as enduring until the continued glacial recession uncovered the strait of Mackinaw. Such correlation seems consistent with Spencer's recorded observations of beaches east and west of the Pewamo outlet,* if the country from Pewamo eastward and from Ypsilanti northeastward to Imlay has since been differentially uplifted, and if the beach noted on the west in the vicinity of Columbia and Allegan, Mich., is referable to the high earliest stage of the glacial lake Michigan before deep erosion of its outlet and northeastward uplifting together sufficed to bring the Pewamo-Saginaw watershed above that outlet past Chicago to the Des Plaines and Illinois rivers. During the Pewamo stage of lake Warren, the glacial lake expanding northward in the basin of lake Michigan as the ice retreated may have held the level of its lowest raised beach at Chicago, only 15 feet above the present lake.

When the strait and island of Mackinaw became uncovered from the ice, one sheet of water is thought by the present writer to have extended over the four upper Laurentian lakes.† The former lake Warren or Pewamo, of the Erie-Huron area, fell about 45 feet, as measured at Cleveland by the vertical interval between the Belmore beach and the Arkona or upper Crittenden beach, the first formed in the Erie basin on a level with the Chicago outlet. After further northeastward uplift of the country, the far extended and chief stage of lake Warren appears to have long held, on the south side of lake Erie, the level of the Forest or lower and principal Crittenden beach, 20 feet below the Arkona level, and about 100 feet above the present lake Erie. During the Arkona and Forest stages lake Warren seems to me to have formed the high shore lines of Mackinaw island, of Green bay, of the northern part of lake Huron, Georgian bay, and lake Nipissing, and of lake Superior, excepting the still higher beaches of the earlier Western Superior glacial lake from Marquette

*Am. Jour. Sci., III, vol. XLI, pp. 201-211, with map, March, 1891.

†Geol. and Nat. Hist. Survey of Minnesota, Twenty-third Annual Report, for 1894, pp. 156-193, with map; also Am. Jour. Sci., III, vol. XLIX, pp. 1-18, with map, Jan., 1895.

and Mt. Josephine westward. That the Chicago outlet, after holding a hight of 15 feet above the present lake Michigan, was uplifted for some time to 30 feet, with accumulation of vast amounts of sand drifted to the south end of lake Michigan in each of its stages above its present hight, shows that the epeirogenic re-elevation from the Champlain subsidence had not always and through all the Laurentian lake region a differential increase from south to north and northeast. Once during the very long continuance of the Chicago outlet and of lake Warren, the uplift was greater at the outlet than on the contiguous southwestern part of the lake Michigan basin. Therefore we need not be surprised that the highest shore of the fully expanded lake Warren fails to rise much above the present lake south of Green bay.

Four glacial lakes preceded and by their union produced the maximum stage of lake Warren, namely, the Western Superior lake, the glacial lake Michigan, the Western Erie lake, and the Pewamo or Erie-Huron lake, which last pre-eminently may be regarded as the early lake Warren, in accordance with Spencer's proposal of that name. Following lake Warren, when the glacial recession permitted outflow from the St. Lawrence basin eastward to the Susquehanna, Mohawk, and Hudson rivers, there ensued lake Algonquin, represented by the Algonquin or Nipissing beach, with outflow along the present bed of lake Erie; lakes Lundy and Newberry; and lakes Iroquois, Hudson-Champlain, and St. Lawrence. Thus a family of eleven important glacial lakes existed in the St. Lawrence basin during the departure of the ice-sheet, distinguished by different outlets and areas, and mostly marked by more numerous beaches northward than southward because the land was being differentially uplifted. W. U.

ANTARCTICA.

The American Society of Naturalists in its recent Philadelphia meeting, held at the same time and in association with that of the Geological Society of America, during the Christmas holidays, discussed very fully the origin and relations of the floras and faunas of the Antarctic and adjacent regions. The series of papers on this subject was as follows:

The Geology of the Antarctic Regions. ANGELO HEILPRIN, Philadelphia Academy of Natural Sciences.

Antarctica Paleontology. W. B. Scott, Princeton University.

Botany. N. L. Britton, Columbia College.

The Terrestrial Invertebrata. A. S. Packard, Brown University.

Vertebrata of the Land; Fishes, Batrachia, and Reptiles. Theo. Gill, Washington.

Vertebrata of the Land; Birds and Mammals. J. A. Allen, American Museum of Natural History, New York.

Vertebrata of the Sea. Theo. Gill, Washington.

Excellent abstracts of these papers are given in Science (new series, vol. iii, pp. 305-320, Feb. 28, 1896), from which some portions of the conclusions of these several investigators are here briefly noted.

Prof. Heilprin thinks "that Antarctica, whether as a continent or in fragmented parts, had a definite connection with one or more of the land masses lying to the north, and the suspicion can hardly be avoided that such connection was, if with nothing else, with at least New Zealand (and, through it, with Australia) and Patagonia."

Prof. Scott, agreeing with this, writes: "The presence of numerous marsupials of distinctively Australian type in the Tertiary rocks of South America is very strong evidence indeed that both of those continents were connected with the Antarctic land. . . . The facts of paleontology may best be explained on the assumption that the Antarctic land mass has at one time or another been connected with Africa, Australia, and South America, which formerly radiated from the South Pole as North America and Eurasia now do from the North Pole."

Prof. Britton finds, however, that the present floras of the extreme southern lands have scarcely a sufficient number of common and closely related species to suggest any former land connection across the Antarctic region in explanation. Many of the instances of genera represented only in South Africa, Patagonia and Chile, and New Zealand and Australia, or on far southern islands, which Prof. Britton cites, seem very remarkable, and it may be acknowledged that the floras do not forbid the hypothesis of a formerly greater Antarctic continent with a temperate climate. Very probably low lands surrounding the pole, with numerous indenting gulfs and inland seas, would not become covered by an ice-sheet, which as it now envelopes the region, may be due to its comparatively late elevation.

Prof. Packard, so far as he is reported, well notes the chief characteristics of the invertebrate fauna of Kerguelen island, but refrains from drawing conclusions as to formerly greater land extension in the Antarctic region.

Dr. Gill's review of the fishes, batrachians, and reptiles of the land is partly summarized thus: "In finally taking into consideration the limited distribution northwards and the close relationship of the species of the several regions referred to, it was urged that the evidence in favor of a former Antarctic continental area was strong, and, in view of the affinities of the species of the now distant regions, the conclusion was logical that the time of disruption was not remote in a geological sense. It was suggested that such disruption might have been coëval with the final uplift of the Andes."

Dr. Allen, from his study of the birds and mammals, believes, on the other hand, that "there seems to be very slight need for calling in the aid of a former Antarctic continent to explain their present distribution."

Lastly, Dr. Gill infers, from the scanty knowledge of marine vertebrate life in the southern circumpolar seas, "that the suppposititious Antarctic continent may have been in all Tertiary geologic times at least deeply indented by extensions of the ocean far towards the Pole."

It is fervently to be hoped that an expedition will erelong spend a part of the summer, or, better still, a whole year, in observations on the meteorologic and magnetic conditions in the vicinity of the southern magnetic pole, and on the geology of portions of the land not ice-enveloped, including the accessible volcanic summits of Mts. Erebus and Terror; and that journeys will also be made to considerable distances and altitudes upon the ice-sheet of that region, affording exact terms for its comparison with the Greenland ice-sheet and with those of North America and northern Europe in the Glacial period.

W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Greenland Icefields, and Life in the North Atlantic; with a New Discussion of the Causes of the Ice Age. By G. Frederick Wright and Warren Upham. Pages xv, 407; with nine maps, and 63 plates and figures, derived from photographs, in the text. (New York: D. Appleton & Co., 1896.) In this little volume the two authors have brought together a great amount of information, descriptive, historical, and scientific, regarding the northwestern part of the Atlantic. They make especial reference, of course, to the great ice-center and ice-radiant of Greenland; but the adjoining region of Labrador receives incidental notice. In the preface and in several of the chapters are found the personal experiences of the senior author, who in 1894 joined the large party of the Miranda scientific expedition to make observations on the glacial phenomena and conditions of this arctic sea. Though unfortunately disappointed in the full realization of their plans and placed for a time in some danger, owing to collisions with ice and rocks, the members of the party made the most use possible of their limited time and opportunity, bringing back results of interest and value, as well as personal recollections that will doubtless last their lifetime. No one could pass through the scenes so well described in the preface without being to some extent changed by them for the rest of his days.

The first part of the work contains an account of the land and sea on the Labrador coast. Incidentally many interesting details of the life of the few inhabitants of that desolate country are woven into the story, giving it a general interest which otherwise it might not possess. But it is only the geological portion of the work that calls for notice here. The author sums up the previous notes of others, chiefly of Packard and Low, showing that the region consists of gneiss with trap dikes, excepting a large area of Cambrian rocks in the north on Ungava bay. These last are "conglomerates, sandstones, slates, shales, and limestones, together with intrusive igneous rocks," and containing large beds of iron ore. Raised beaches indicate recent elevation from Henley Harbor to the northward. The rugged and angular outlines of the mountains of northern Labrador, strown with frost-riven blocks of local origin above the altitude of 2,000 feet, prove that these mountains near Cape Chidley were not covered with an ice-sheet.

The fourth chapter consists of a narrative of Prof. Wright's excursions on the Greenland coast, including an examination of the large glacier at the head of Ikamiut fjord and of numerous smaller glaciers on its sides. One fact was noted wherein these small ice masses, called "hanging glaciers," differ from the more familiar glaciers of the Alps. In consequence of the coolness of the climate they thicken towards their ends, the upper portion pushing down over the lower as the slope of the bed decreases.

The chapter on the flora of Greenland, which is chiefly based on the works of Dr. Henry Rink and Dr. Robert Brown, interests the geologist by showing how large a number of plants can flourish close to the edge of this immense sheet of ice and even upon the "nunataks" that rise through it. "For example, on Jensen's nunataks, a cluster of rocky peaks rising 100 to 500 feet above the inland ice, at a distance of nearly 50 miles back......Kornerup, the geologist and botanist of Lieutenant Jensen's party, in 1878, collected 27 species of flowering plants. The ice surface there is 4,900 to 5,150 feet, or nearly one mile, above the sea; and the nunatak summits vary in height from 5,200 to 5,650 feet." The bearing of the distribution of the 770 species of arctic phænogams, listed by Sir Joseph Hooker, on the former changes of configuration of the land and water, is another point in which the studies and results of the botanist possess great value for the geologist. Prof. Asa Gray, quoted by our author (on page 201), has pointed out that the flora of Greenland is largely European, while that of Labrador and the west coast of Davis strait is mainly American, indicating the very ancient date of this deep water channel between the two lands. This chapter, and all that follow, excepting the final one, are Mr. Upham's contribution to the work.

A condensed account of the animal life of Greenland, and a sketch of the various attempts to explore the vast, desolate, interior expanse of ice and snow, conclude the descriptive portion of the volume; and the remainder consists of a discussion on the relations of the present glaciation of Greenland with the Pleistocene glacial geology of this continent and of Europe.

In the latter portion Mr. Upham has summed up most of the evidence recently gathered from many sources on the disputed questions connected with the causes, stages or epochs, and duration of the Ice age. This is not the place for entering on any statement of the special doctrines advocated. Mr. Upham's views were already known by glacialists, and will here reach the wide range of general readers. Suffice it to say that the summary presented is well put together and fairly balanced. In the last chapter Prof. Wright reviews this discussion, mainly agreeing with it, but attributing perhaps a larger share of the climatic conditions of the Ice age to changes of the oceanic circulation, acting conjointly with great elevation of the lands which became ice-enveloped.

The work is very readable and of much general interest. It is well and fully illustrated with excellent photographic views, which give a clearer idea of the scenery and surroundings of the localities visited than long written descriptions could do. The remarks on the natives and their conditions of life are dispassionate and prudent. Professor Wright recognizes the unwisdom of attempting to introduce European ways of living in that inhospitable clime, and admits that if men live there at all they must live nearly as do the Eskimos. Any civilization of a much higher grade is impossible when the struggle for existence is so severe as to lead to practices like some which he describes. They show a direct conflict between the instinct of preservation of the tribe and that of natural affection. E. W. C.

Unter-Tertiäre Selachier aus Südrussland. By Dr. Otto Jaekel. (Mémoires du Comité Géologique, vol. ix, no. 4, pp. 1-35, 1895.) In this paper Dr. Jaekel describes a number of selachian remains from the Lower and Middle Oligocene of two provinces in South Russia. The material is chiefly interesting on account of the limited number of forms occurring in these deposits, and the certainty of referring to one and the same species a series of teeth which present a considerable range of variation among themselves. This favorable circumstance, in the author's opinion, affords the key to an understanding of the dentition of the several forms represented; and the specimens are accordingly described as pertaining to definite regions of the mouth, from analogy with recent forms.

Four of the seven genera that are described belong to the family *Lamnidæ*, one of them, *Hypotodus*, being new; the remainder are fragments of *Carcharias*, *Notidanus* and *Myliobatis*. In the descriptions of *Carcharodon* one can but note the contrast between what may be called the German method and that followed by the English and other schools, namely, the tendency to isolate and individualize minor distinctions and to split up larger groups into a number of smaller ones. For instance, Dr. Jaekel retains the genus *Otodus* in its primitive sense, the species of which are now generally distributed among *Lamna*, *Carcharodon* and *Oxyrhina*; he recognizes three species of the last named genus, whereas most authors admit only two; and he holds that the majority of *Carcharodon* species described by the older authors are distinct, while A. S. Woodward, in his "Catalogue of Fossil Fishes," includes no less than eleven of these under the synonymy of *C. auriculatus* (Blv.).

But in this paper the author exceeds even Agassiz in his tendency toward minute differentiation. Agassiz's *Odontaspis verticalis*, from the London clay of Sheppy, which has always been regarded as a "good" species of *Odontaspis*, now finds itself elevated to be the type of a new genus, *Hypotodus*, and a new Russian species (*H. trigonalis*) is placed alongside of it. Moreover, owing to the author's inability to bring two of the Russian specimens of *Carcharodon* into perfect agreement with any one of Agassiz's figures, he proposes the new specific title of *C. sokolowi* for a form which may be readily associated with *C. auriculatus*. The most extreme position of all, however, is taken by Dr. Jaekel in regard to the genus *Oxyrhina*, which he states to be "traceable with certainty only as far back as the Eocene;" some of the Cretaceous forms that are usually placed here, being, in his opinion, unquestionably referable to other genera.

It is doubtful whether the majority of paleichthyologists will agree with all of these conclusions. In regard to the last mentioned, it need only be pointed out that *Oxyrhina* is as typically a Cretaceous genus as is *Otodus* auct., which Jaekel still upholds; the only noteworthy distinction between them consisting in the presence or absence of lateral denticles. Not only have Lawley's researches made known the nearly complete dentition of certain Tertiary species of *Oxyrhina*, but its Cretaceous representatives, described by Bassani and the writer, furnish the most perfectly preserved individuals known among the *Lamnidæ*. Except for the reduction in size, the dentition of *Oxyrhina* has remained practically unaltered since its initiation in the Cretaceous; the allied genus *Carcharodon* has also suffered a diminution in size, but it is reasonable to suppose its dentition has not been otherwise affected.

Now, the Italian paleontologists have demonstrated, by means of the more or less complete dentition occurring *in situ*, that over half a dozen Tertiary species of *Oxyrhina* founded on detached teeth are identical with the common *O. hastalis*; and that at least three "species" of fossil *Carcharodon* teeth represent merely different portions of the dentition of *C. rondeletti*, which is still existing. By analogy, then, we should expect that the complete dentition of *C. auriculatus*, which is the type of *Carcharodon* teeth having large lateral denticles, would reveal a series of teeth differing among themselves to a like extent; and such an amplitude would abundantly include all of the forms which Woodward and others hold as synonymous with *C. auriculatus*, but which Jaekel regards as distinct.

The author's failure to take the variations due to the relative position in the mouth sufficiently into account is shown in yet another instance, where he describes certain small teeth of *Carcharodon turgidus* as pertaining to the symphysis. Although admitting that symphysial teeth are absent in the recent species of *Carcharodon*, he can conceive of no other explanation of their origin, "unless, indeed, they should be of pathologic nature." A more careful comparison of these teeth with the dentition of recent *Lamnidæ* would doubtless have convinced the author that they occupied the posterior angles of the mouth; or, to adopt the term first suggested by Dr. Otto Reis, they are "Mundwinkelzähne." Apart from these minor defects the paper is an excellent one and forms a welcome addition to our knowledge of the fossil fish fauna of Russia.

C. R. E.

The Geological Structure of the western part of the Vermilion Range, Minnesota. By Henry Lloyd Smyth and J. Ralph Finlay. (Trans. Am. Inst. Mining Eng., Atlanta meeting, 51 pp., 1895.) After brief references to the work of earlier geologists on the rocks and the structure of the region the authors divide the sedimentary rocks of the Vermilion range into two divisions, viz., a slate formation and the iron-bearing formation, of which the former is the older. This succession they deduce from an examination of numerous outcrops on the shores of Vermilion lake and about the mines. Although on page 8 they state that the iron formation is "to all appearance quite devoid of clastic material," it has "clearly the structure of sedimentary rock" (p. 11). They suppose that the strata have undergone profound chemical rearrangement. The slate formation is less changed--a fact which is believed to be due to their "poverty in coarser detrital materials," to their chemical composition and to their extremely fine grain. As to the origin of the silica of the jaspers, the authors are inclined to consider it as the ultimate product of oxidation from some earlier sedimentary rocks.

The igneous rocks of the region they consider wholly intrusive and of later date than the sedimentary—whether acid or basic. The acid igneous rocks were originally in the form of quartz porphyries and felsytes, but by fracture, pressure and shearing have been converted into sericite schists and breccia conglomerates. They involve fragments of the slate formation and of the jaspers, but only as portions "plucked from the strata" through which they were intruded. The conglomerate at Stuntz island they consider one of the brecciated intrusives of the acid series, and not a true conglomerate.

In some manner the apparently fragmental and even bouldery aspect of the greenstones, whether at Soudan or at Ely, they attribute to the brecciation of an original, massive, basic eruptive.

The merchantable deposits of the ore they believe to have been formed from local causes tending to concentration of iron oxide at favorable points. Thus the accidental posé of a basic eruptive, as it pierced the strata, afforded routes of underground drainage along which surface waters entered, carrying organic matters. These waters became alkaline, removed silica and deposited iron oxide.

The authors have made an important contribution to the geology of an interesting and complicated region. Their conclusions differ from those of the Minnesota survey in several important particulars. It may be they are correct. But there are some difficulties which remain which their theory does not fully explain. It is not best here to discuss them. It is only necessary to remark that, while we consider their contribution a very welcome addition to a progressive investigation, the result is not closed. N. H. W.

British Geology. By T. Mellard Reade. (Geological Magazine, decade IV, vol. II, pp. 557-565, 1895.) In his recent presidential address to the Liverpool Geological Society Mr. Reade shows briefly the part that the geology of the British isles takes in illustrating the origin of mountain ranges. In this connection he gives a summary of his latest opinions regarding the cause of orographic movements and ascribes it entirely to changes of temperature, producing expansion and contraction, and not to the shrinkage of the nucleus of the earth, the closing in of the non-shrinking crust upon it and the consequent folding by tangential pressure. In concluding he says that "Neither does the principle of isostacy so insisted upon by American geologists explain the compression, folding and building up of great masses of sediment into mountain ranges. On the principle of isostacy, it must be obvious to anyone possessing even a rudimentary acquaintance with mechanics that the sinking of the bed of the seas on which great deposits are accumulating, and to some extent a rise of surrounding land, may be explained, but not the lateral compression and elevation of the sediments themselves into mountain ranges.

"Where, then, are we to look for the agency constantly associated with the deposit of great volumes of sediment which is capable of eventually upheaving them from below the sea level, and by lateral compression and folding throwing them into mountain chains?

"Again, when after the lapse of lengthened periods of geological time, denudation has cut away and removed into the sea large masses of elevated land, what agency is it that causes it to shrink and become traversed by great lines of faulting?

"It appears to me now, even more vividly than it has done in the past, that the only agency with which we are acquainted, constantly associated with sedimentation and denudation, and capable of these enormous dynamical effects, is change of temperature; that expansion by increase of heat is the cause of the folding, compression and upheaval of rocks, while loss of heat and consequent shrinkage is the cause of the earth fractures known as normal faults. This principle I explained fully in 1886, in my 'Origin of Mountain Ranges;" since then the theory has been subjected to much criticism, ranging from a questioning of fundamental principles down to a minor examination of small details.

"The fundamental position has, I maintain, not been shaken, either by mathematical physics or geological facts. The more the theory is tested by the light of practical geology the more remarkable is the explanation it affords of the associated phenomena of sedimentation and mountain-building, denudation and faulting. Furthermore, no other theory yet brought forward attempts to offer an explanation of more than one set of these phenomena, namely, those of compression. Normal faulting cannot be accounted for by compression, yet the rival theory of tangential pressure on the crust through the shrinkage of the earth's nucleus provides for compression only. Contraction, by which I have shown that normal faults are produced, is not part of the machinery of any other theory than the one associated with my name.

"I ask geologists to bring to the consideration of these great problems clearness of vision, for, usually, a single aspect only is examined, the rest being left in an impenetrable haze." C. R. K.

Les Spirifères du Coblenzien Belge. Par FERD. BÉCLARD. (Bull. de la Société de Géologie, de Paléontologie, et d'Hydrologie, tome IX, pp. 129-240, 5 pls., Nov., 1895.) Few paleontological papers illustrate more clearly the modern rebound from the tendency which has existed for years past of excessive species making, than does the admirable little memoir which M. Béclard has just issued on the spirifers of the lower Devonian or Coblenzien group of Belgium. Of the three score forms of the genus which have been ascribed to these beds only eight are now recognized as valid species. These are: *Spirifer primævus* Steininger, *S. hystericus* Schlotheim, *S. subcuspidatus* Schnur, *S. ardnennensis* Schnur, *S. cultrijugatus* Roemer, *S. paradoxus* Scholtheim, *S. dalei densis* Steininger and *S. trigeri* de Verneuil.

The paper is essentially a critical review and revision. All the data and reasons for changes in nomenclature are given at length. If any criticism is to be made on the treatment of the subject it would be that it is more prolix than is generally desirable, but this very prolixity is, in this case, doubtless necessary in order not to leave the slightest ground for questioning the accuracy of judgment in making what will to many of those who use the work appear as innovations entirely too radical.

Seldom does a work appear in which the criticisms are so full of detail, so unbiased in their treatment and so clearly set forth in logical sequence. Each species is uniformally and symmetrically discussed.

There are given under each: (1) a summary of the observations of those authors who have contributed to a knowledge of the particular species; (2) references, which, though inaccessible, are an aid in the determination of the geological range and geographical distribution; (3) a comparison of the invalid forms; (5) a discussion of the forms related to the types; and lastly (6) the author's own observations. Five large triple plates accompany the memoir. C. R. K.

The Physical Features and Geology of the Route of the proposed Ottawa Canal between the St. Lawrence River and Lake Huron. By R. W. ELLS and A. E. BARLOW. (Trans. Royal Society of Canada, second series, vol. I, section IV, pp. 163-190, with map; 1895.) This paper presents a hydrographic and geologic description of the route surveyed, with a series of carefully determined altitudes of the rivers and lakes, in their stages of low and high water. The route follows the Ottawa and Mattawa rivers to the source of the latter in Trout lake, 667 feet above the sea. A watershed which is reported to be less than three feet higher divides this from lake Nipissing, only about three miles distant, lying 25 feet below Trout lake; and its outlet, French river, has a descent of 61 feet to lake Huron. The question whether an outflow from the lake Huron basin, since the retreat of the ice-sheet, passed eastward across this watershed, as supposed by Gilbert, Wright, and Spencer, is not here taken up; but elsewhere Mr. Barlow and Dr. Robert Bell have expressed their opinions against that hypothesis. The character and origin of the Archæan formations, which occupy nearly all the country from Allumette island of the Ottawa river to Georgian bay, and the history of their investigation by Canadian geologists, are quite fully considered. Within the last ten years it has been shown "that many of these rocks, formerly supposed to be sedimentary, are, in fact, truly igneous masses." W. U.

The Physical Geography of Southern New England. By W. M. DAVIS. (National Geographic Monographs; American Book Co., New York, 1895.) This article traces the origin of the upland of New England as a very ancient peneplain of erosion on which rise a few old relics of yet higher land in the shape of "monadnocks" or isolated points that have survived the base-level erosion. The dissection of this peneplain is next explained, the date of the uplift being uncertain. The action of the rivers in this work comes next, that of the Connecticut standing foremost, and in this connection the author very justly points out that the great size of this valley is not due simply to the size of its contained river, and also that the broad Connecticut lowland is the first step to a lower plain or base-level which must some day be reached. The lava ridges, incipient "monadnocks" of the second peneplain, are next discussed and the essay concludes with a notice of the relation of population to the physical geography of a region. The paper is illustrated by several excellent photographic reproductions. E. W. C.

The Geology of Moriah and Westport Townships, Essex County, N. Y. By JAMES FURMAN KEMP. (Bulletin of the New York State Museum, vol. 3, no. 14, pp. 325-355, with maps and sections; Sept., 1895.) The detailed areal and structural geology of these townships, including part of the eastern border of the Adirondacks, and extending from Crown Point fifteen miles north to Split Rock mine, on the shore of lake Champlain, is here elaborately mapped and described. Very extensive deposits of magnetite, attaining in one mine a thickness of 200 to 300 feet, are found in the older gneisses. The district also has other vast masses of magnetite which are worthless for mining on account of their being titaniferous, and these "invariably occur in dark, basic gabbros and in such relations as to make the inference unavoidable, that they are excessively ferruginous or basic portions of the original igneous magma." W. U.

Geological History of the Chautauqua Grape Belt. By R. S. TARR. (Bulletin 109, Cornell University Agricultural Experiment Station, pp. 91-122, with figures 48-71 in the text, including maps, sections, and views from photographs; Jan., 1896.) Attention is chiefly directed to the beaches of the glacial lake Warren, their resemblance to the present shore of lake Erie, and their relationship to the moraines. The principal grape belt narrowly skirts lake Erie, reaching from the shore upward about 200 feet. Its soil was much modified by ancient lacustrine action, and its climate is now much influenced by the broad lake on its windward side. W. U.

On Dikes of Oligocene Sandstone in the Neocomian Clays of the District of Alatyr, in Russia. By A. P. PAVLOW. (Geol. Magazine, n. s., dec. 4, vol. 3, pp. 49-53, pl. 5, Feb., 1896.) The dike described is from 12 to 14 inches in width, stands nearly vertical, and is composed of quartz sand mixed with glauconite grains. The country rocks, which are cut by the dike, are clays of lower Cretaceous age, and the dike itself contains fossils of the Tertiary. The author suggests that, a fissure being formed in the clays, the overlying sandstone, still unconsolidated, simply fell in and filled the fissure. He uses the term "Neptunic dikes" for these dikes of sedimentary rock. U. S. G.

RECENT PUBLICATIONS.

1. *Government and State Reports.*

Report of the Department of Mines, Nova Scotia, for the year ending Sept 30, 1895. Edwin Gilpin, Jr., inspector of mines. 88 pp., Halifax, 1896.

U. S. Geol. Survey, Bull. 133. Contributions to the Cretaceous paleontology of the Pacific coast: The fauna of the Knoxville beds, T. W. Stanton. 132 pp., 20 pls., 1895.

Illinois State Museum, Bull 8. Description of new and remarkable fossils from the Palæozoic rocks of the Mississippi valley, S. A. Miller and W. F. E. Gurley. 65 pp., 5 pls., Feb. 18, 1896.

Iowa Geol. Sur. Administrative reports, Samuel Calvin, H. F. Bain, W. H. Norton, A. G. Leonard. Vol. 5, pp. 8-31, 1896.

Missouri Geol. Sur. Sheet report 4: A report on the Mine la Motte sheet, C. R. Keyes. Pp. 1-132, pls. 1-14, map, 1895.

Geol. Sur. of Canada. Summary report of the Geological Survey Department for the year 1895, G. M. Dawson. 154 pp., 1896. Price 10 cents.

II. Proceedings of Scientific Societies.

Bull. Amer. Museum Nat. Hist., vol. 7, 1895. Fossil mammals of the Puerco beds (collection of 1892), H. F. Osborn and Chas. Earle; Fossil mammals of the Uinta basin (expedition of 1894), H. F. Osborn; On the osteology of Agriochœrus, J. L. Wortman; Notes on some specimens of minerals from Washington heights, New York City, E. O. Hovey; Perissodactyls of the lower Miocene White River beds, H. F. Osborn and J. L. Wortman.

Proc. Acad. Nat. Sci. Phila., 1895, pt. 3, 1896. Preliminary note on a new alkali mineral, W. M. Foote; The fossil Vertebrata from the fissure at Port Kennedy, Pa., E. D. Cope; The Port Kennedy deposit, Angelo Heilprin; Trap dykes in Chester Co., Pa., T. D. Rand.

Bull. Geol. Soc. Amer., vol. 7, pp. 135-170, Jan. 10, 1896. Studies of Melonites multiporus, R. T. Jackson and T. A. Jaggar, Jr.

Same, pp. 171-254, pls. 2-9, Jan. 31, 1896. Studies of Palæechinoidea, R. T. Jackson.

Same, pp. 255-314, pls. 10-14, Feb. 4, 1896. Decomposition of rocks in Brazil, J. C. Branner.

Bull. of the Nat. Hist. Soc. of New Brunswick, no. 13, 1896. The volcanic rocks of the maritime provinces of Canada, W. D. Matthew.

III. Papers in Scientific Journals.

Science, Feb. 14. The age of the Philadelphia brick clay, G. F. Wright.

Science, Feb. 21. Current notes on physiography, W. M. Davis.

Science, Feb. 28. The origin and relations of the floras and faunas of the Antarctic and adjacent regions, Angelo Heilprin, W. B. Scott, N. L. Britton, A. S. Packard, Theo. Gill, J. A. Allen.

Science, Mch. 13. Notes on the Cerillos coal fields, J. J. Stevenson; Current notes on physiography, W. M. Davis.

Amer. Jour. Sci., Mch. Recent and fossil tapirs, J. B. Hatcher; Results of recent pendulum observations, G. R. Putnam; Trinidad pitch, S. F. Peckham and Laura A. Linton; Meteorite from Forsyth Co., North Carolina, E. A. de Schweinitz; New alkali hornblende and a titaniferous andradite from the nepheline-syenite of Dungannon, Hastings Co., Ontario, F. D. Adams and J. B. Harrington; Proofs of the rising of the land around Hudson bay, Robert Bell; Occurrence of thausmasite at West Paterson, New Jersey, S. L. Penfield and J. H. Pratt; Age of the Wealden, O. C. Marsh.

School of Mines Quarterly, Jan. Lecture notes on rocks, J. F. Kemp.

Am. Naturalist, Mch. The history and principles of geology and its aim, J. C. Hartzell, Jr.: Life before fossils, Charles Morris; On the occurrence of Neocene marine Diatomaceæ near New York, A. M. Edwards.

IV. Excerpts and Individual Publications.

The physical features and geology of the route of the proposed Ottawa canal between the St. Lawrence river and lake Huron, R. W. Ells and A. E. Barlow. Trans. Roy. Soc. Canada, 2d ser., vol. 1, sec. 4, pp. 163-190, map, 1895.

Geological history of the Chautauqua grape belt, R. S. Tarr. Cornell Univ. Agrl. Exp. Station, Bull. 109, pp. 90-122, 1896.

Ueber Lawsonit, ein neües gesteinsbildendes Mineral aus Californien, F. H. Ransome and Ch. Palache. Zeitsch. f. Krystallog., Bd. 25, pp. 531-537, pl. 7, 1896.

The Saint Peter Sandstone, F. W. Sardeson. Bull. Minnesota Acad. Nat. Sci., vol. 4, no. 1, pp. 64-88, pls. 2-4, 1896.

Life, Letters and Works of Louis Agassiz, Jules Marcou. 8vo, 2 vols. xi+302 and viii+318 pp.; New York, Macmillan and Co., 1896. Price $4.

The LeClaire limestone, Samuel Calvin. Bull. Lab. Nat. Sci. State Univ. Iowa, vol. 3, no. 4, pp. 183-189, 2 pls.; March 16, 1896.

V. Proceedings of Scientific Laboratories, etc.

Bull. Sci. Labor. Denison Univ., vol. 9, pt. 2, Dec., 1895. The Palæozoic formation, W. F. Cooper; Preglacial and recent drainage channels in Ross county, Ohio, Gerard Fowke; A preglacial tributary to Paint creek and its relation to the Beech flats of Pike county, Ohio, W. G. Tight.

Bull. Dept. of Geol. Univ. of Cal., vol. 1, no. 12, pp. 337-362, pl. 18, Mch., 1896. On malignite, a family of basic plutonic orthoclase rocks rich in alkalies and lime, intrusive in the Coutchiching schists of Poohbah lake, A. C. Lawson.

CORRESPONDENCE.

Preliminary Notes on Studies of the Great Lakes made in 1895. The work of exploring the coastal slopes of the Great Lakes with a view of studying their glacial and postglacial history was resumed about the middle of June of last year and continued at intervals until the end of October. Some of the regions visited were critical, that is to say, they might reasonably be expected to yield results that would be decisive in their bearing on certain questions that have been more or less in controversy. I offer the following preliminary notes on some of the more important results and a few remarks on their relations to views previously expressed.

About five weeks were spent in exploring the coasts of the lower peninsula of Michigan. The ground covered extends from the west side of Saginaw bay northward to the Strait of Mackinac and southward on the coast of lake Michigan from Mackinac to Manistee. The results of this work were satisfactory to a degree. Both the Algonquin and Nipissing beaches were found developed in fine form, and both were traced with substantial continuity from their nodal points on the east coast northward and upward to the strait, and then southward and downward to their nodal points on the west coast. The altitude and position of the beaches departed from expectation, as previously calculated from their place in surrounding areas (AM. GEOLOGIST, Feb. and March, 1895; Am. Jour. Sci., April, 1895), in only two or three instances and to a very slight degree. The places on the Michigan shore described in an earlier paper (Am. Jour. Sci., March, 1892) were revisited and examined more closely.

The month of September was spent on the north coast of lake Superior. Several of Prof. Lawson's localities were visited, and his descriptions (Twentieth Ann. Rept., Minn. Geol. and Nat. Hist. Survey) of the shore lines were verified in every case. The Nipissing beach is very pronounced in its development and was clearly recognized along the whole coast, rising from 61 feet (levelled by Lawson) above the lake in Port Arthur to about 115 feet (aneroid) at Peninsula Harbor in the extreme northeast. It is hard to see how Prof. Lawson could have failed to recognize the identity and continuity of this strand. It was readily distinguished by its accustomed characters at every place visited on this shore. His scheme of correlation was clearly disproved so far as relates to the lower strands; and my paper (AM. GEOLOGIST, May, 1895), discussing the significance of his observations on these beaches, stands fully justified.

On the higher beaches, however, my results, so far as they go, seem to indicate that Prof. Lawson's belief that they are approximately horizontal is substantially correct. So far as I could discover, the highest distinctly wave-made beach in the vicinity of Port Arthur is about 440 to 450 feet above the lake. (Lawson gives the delta at Kaministiquia station as 455 feet.) This strand was found near Port Arthur at three other places besides the one mentioned by Lawson. But while no beach properly so called was found above this one, a very remarkable lacustrine deposit of fine red clay was found in the valley of Sunshine creek, a tributary of the Kaministiquia, and extending for several miles up the Canadian Pacific railway main line. At about 875 to 900 feet above the lake the clay was succeeded by a zone of sand and washed gravel. No beach ridges were seen, but no very favorable situation for their production came in view. The impression at the time was that this was probably a local lake filling the Kaministiquia and White Fish valleys and their tributaries and held in on the east by the ice-sheet in the vicinity of Port Arthur.

Farther north and east the results appear to be quite contrary to anticipation. (AM. GEOLOGIST, June, 1894; Am. Jour. Sci., Jan. and April, 1895.) The places where the higher beaches were seen fall chiefly in two groups, one in the region of Thunder bay, and the other, which I call the Jackfish group, extending eastward from Schreiber. The intervening gap of 60 to 70 miles is too great for the assumption of continuity and identity to be made with entire safety. Nevertheless it seems probable, from similarities of character and from substantial horizontality in each of the two groups, that the upper strongly developed beaches in the two are really one continuous line. In the Jackfish group the highest beach varies from 400 to 430 feet above the lake. The higher ground was examined, as well as the extreme roughness of the country permitted, at each locality. But no evidence of higher submergence was found. From Heron Bay, on the Canadian Pacific railway, eastward up the valley of the White river to the summit at O'Brien, no strand and no lake sediments were found above the main beach near Cache lake at about 420 or 430 feet above the lake. Missinaibi was also visited. The altitude of this pass across the Height of Land was found, by the C. P. R. profile, to be about 75 feet higher than the figure quoted by Prof. Lawson. No evidence of a former strait was found here nor at Jackfish, which is near the pass to lake Kenogami. The upper beach thus appears to be 85 to 90 feet below both passes. If the main upper beaches in the two groups of localities mentioned are one, it would seem to indicate that instead of rising toward the north or northeast, this beach has a very slight declivity in that direction. Still, it is very nearly horizontal. If these beaches are not one line it seems probable that the one in the Jackfish group is the younger and lower. The highest beach descends westward from L'Anse on the south shore, and apparently southwestward from Mt. Josephine on the north shore; and so does the Nipissing beach at a lower level. It would disclose a curious history for this basin to find a horizontal beach between these two, or one sloping slightly in the opposite direction.

It is hardly to be imagined that there could ever have been a glacial or any other kind of barrier between the Jackfish group of beaches and Sault Ste. Marie, where the highest beach at Root river is 414 feet above lake Superior. The latter is now identified beyond a shadow of doubt as the Algonquin beach of the Huron basin, and hence the former is probably the same. There is still perhaps a little doubt as to the identity of this beach in the western part of the Superior basin. Some of the intervals between present points of observation are too wide to be bridged by inference with perfect safety.

These facts completely overthrow the conclusions which I advanced in papers published one and two years ago (see last reference above). Throughout my study of the lake region, begun systematically in the summer of 1890, I have kept in mind two alternative hypotheses for the origin of the highest beaches north of the latitude of Petoskey. First, that they were marine and were therefore made by the sea, which entered the lake basins; or, second, that they were made by ice-dammed lakes during the glacial recession. The marine hypothesis seemed the more plausible of the two. In accordance with it I expected to find straits northward from the Superior basin to Hudson bay and high shore lines extending eastward from the hills near lake Nipissing to the Ottawa valley. All the beaches south of the parallel of Petoskey, however, were attributed to glacial lakes and the efficiency of the glacier to act as a dam for waters of such magnitude was never questioned. The marine hypothesis was held for other reasons. In the first season's work I thought I discovered a rather sudden break in the ancient water planes at Petoskey ; and there is in fact a change of gradient near that place, although, as I have since found, it does not appear so conspicuously anywhere else on that parallel. Another error, as it now appears, was the assumption that the highest beach of the north end of Green Bay is continuous with that back of Marquette. The interval of distance was too great for the inference of continuity. I entertain no doubt now that the beach at the former place was made after the withdrawal of an ice-dam which held up the water at the latter.

To my mind the disproof of the northward straits from lake Superior greatly weakens the marine hypothesis, and it strengthens the glacial hypothesis correspondingly. I was still further impressed with the easy possibility of an ice dam for lake Algonquin, when I visited the deep narrow valley of the Ottawa river. In short, by the past season's explorations, the relation between my two working hypotheses is completely reversed. The primary presumption is now strongly in favor of the ice barrier, while the marine hypothesis has fallen far behind, almost out of sight. A small residue of facts in the basin of lake Temiscamang still suggests the possibility of a short, shallow marine invasion of the Great Lakes. But this possibility is remote and will probably vanish on more complete investigation. If lake Algonquin was glacial, there is little reason left to suppose that lakes Iroquois and Agassiz were not the same.

The acceptance of these views necessitates a radical revision of two or three of my earlier papers, especially with reference to certain names used in them. What I called the "Chippewa" beach (Am. Jour. Sci., April, 1895) is in reality the northern extension of the Algonquin beach, and the term "Chippewa" so used will therefore be dropped. The terms "First" and "Second," as applied to two supposed similar stages of lake Algonquin (Am. Geologist, Feb. and March, 1895), will also be dropped, the name "lake Algonquin" remaining as previously used by Prof. Spencer. It becomes necessary also to find some appropriate name for the waters which made the Nipissing beach, and it seems very desirable to use the word Nipissing. The three upper lakes at this period were three separate bodies of water just as they are to-day. Hence, in place of the name "Second Lake Algonquin" I have adopted the name "Nipissing Great Lakes," and so we may speak of the Nipissing beach of the Nipissing Great Lakes, just as we do of the Algonquin beach of lake Algonquin and the Iroquois beach of lake Iroquois. The facts gathered and recorded in the papers already published are not affected in any way by this change of hypothesis, except that they are put in better order by it.

The lake history is now so far worked out that I can state without fear of contradiction that there are only two great, strongly developed shore lines which mark critical lake stages for the whole area of the three upper basins. These are the Algonquin and Nipissing beaches. No doubt there are weaker lines of similar extent between the horizons of these two. But there is none above the Algonquin plane. The beaches of lake Warren do not extend northward beyond Alpena, if indeed they reach that place. I found them on the west side of Saginaw bay, but no trace of them along the face of the highlands which extend eastward from Petoskey past Rogers City nearly to Alpena. The higher beaches of the western end of the Superior basin have no extension southward over the Green bay area; nor do any of the beaches which connect with the Chicago outlet reach as far north as Escanaba. My own observations seem conclusive on these points. Lake Warren had its outlet westward through the Pewamo channel into the Michigan glacial lake, and this emptied through Chicago. But lake Warren never extended around the north side of Michigan, nor did it ever include any part of the Superior basin. Neither the Algonquin nor the Nipissing beaches have any connection with the Chicago outlet, nor do either of them extend to the Erie basin. Both pass to, or a little below, the head of the St. Clair river.

The month of October was spent in the vicinity of North Bay, Ontario, and in the Mattawa and Ottawa valleys. Some interesting observations were made, but space forbids any account of them here.

Fort Wayne, Ind., Feb. 15, 1896. FRANK B. TAYLOR.

PERSONAL AND SCIENTIFIC NEWS.

PROF. ALEXANDER AGASSIZ has gone to Australia to investigate the Great Barrier reef.

DR. OTTO MUEGGE has been appointed professor of mineralogy in the University of Königsberg.

A NEW METEORIC IRON from Forsyth Co., North Carolina, is described by Dr. E. A. de Schweinitz in the American Journal of Science for March.

THE ST. PETERSBURG ACADEMY OF SCIENCE has elected PROF. JAMES HALL an honorary foreign member and MR. C. D. WALCOTT a corresponding member.

MR. J. E. MARR, F. R. S., Fellow of St. John's College, has been reappointed university lecturer in geology at the University of Cambridge for a term of five years.

PROF. GRENVILLE A. J. COLE, has recently issued (through Griffin and Co., of London) an interesting volume entitled "Open-air Studies: an Introduction to Geology Out-of-doors."

DR. LEIDY'S delayed posthumous memoir on fossil vertebrates from the Alachua clays of Florida is now in press and will appear as a part of the transactions of the Wagner Free Institute of Science. (*Science.*)

LORD KELVIN this year reaches his jubilee as professor of natural philosophy in the University of Glasgow. The event will be celebrated on June 15th and 16th by the city of Glasgow and by the students of the University.

THE HON. WALTER B. D. MANTELL, son of the geologist, Dr. Gideon Algernon Mantell, and himself well known in the same field of science, died at Wellington, New Zealand, Sept. 7th, 1895, aged 75. He settled in New Zealand in 1840 and furnished much material to his father from the then almost untouched fossil remains of the great wingless birds of those islands.

THE IDAHO MINING NEWS is a new mining journal whose first number appeared in March. It contains: "The Boise gold belt" by James Gunn; "Geology and vein structure of the Boise gold belt" by J. B. Hastings; "The coal fields of the Payette river" by Robert Forrester. This paper is published monthly by the Idaho Mining Exchange, Boise, Idaho; the price is $1.00 per year.

THE NORTHWEST MINING ASSOCIATION held a meeting of its officials, at which about 100 were present, in Spokane, Wash., Feb. 22d. A number of papers on practical mining matters were presented and the secretary, Mr. L. K. Armstrong, addressed the Association on "The importance of geological surveys." The next meeting will occur on Oct. 3d, and will be of three or four day's duration.

THE AMERICAN INSTITUTE OF MINING ENGINEERS held its seventieth meeting at Pittsburg, beginning on Feb. 18th. The following papers relating to geological subjects were presented:

The ore deposits of the Australian Broken Hill Consols mine, Broken Hill, New South Wales. GEO. SMITH.

Vein walls. T. A. RICKARD.

Copper ores in the Permian formation of Texas. E. J. SCHWARTZ.

DR. C. S. DU RICHE PRELLER, in the March number of the *Geological Magazine*, describes the emptying of the Merjelen lake through its barrier, the Aletsch glacier, during the night of the 23d of last September. The lake had risen within about one and a half feet of reaching the artificial tunnel recently cut for its overflow to the Viesch valley, 23 feet below the natural watershed. An instructive engraving of the lake and glacier, from a photograph, accompanies this article.

ANOTHER PAPER BY DR. PRELLER, in the same magazine, gives an account of the ice-avalanche which occurred on the Gemmi pass, 6,400 feet above the sea, early in the morning of September 11th. The volume of the detached glacier and rock débris was about four million cubic meters, weighing somewhat more than the same number of tons; it fell from a hight of about 3,500 to 4,500 feet on the steep mountain slope above the pass; a part of the mass was carried forward by its impetus up a hight of 1,300 feet to the summit of the precipitous ridge on the opposite side of the valley; and all this disaster, involving the loss of six people and more than 150 head of cattle, probably occupied, according to computations of the velocity of falling bodies, no more than one minute.

Dr. Ludwig Rutimeyer, professor of zoology and comparative anatomy in the University of Basel, died on Nov. 26th, 1895, aged 70. Among his more important works are "Untersuchungen der Thierreste aus dem Pfahlbauten in der Schweiz," and "Beiträge zur Kentnisse der fossilen Pferde und zu einer vergleichenden Odontographie der Hufthiere in Allgemeinen." In the former he reviews the condition of the early races of domestic animals in the lake dwellings of Switzerland. The latter is a study of the comparative morphology of the teeth and it has served as a foundation of much of the subsequent work on this subject, especially of the work done by American paleontologists.

A supposed meteorite explosion is recorded from Madrid on Feb. 10th. The Madrid Observatory issued the following: "At 9.29 this morning a strong light was observed proceeding from a small cloud moving from the southwest to northeast. A minute and a half latter a terrific report, followed by several others of less intensity, occurred, accompanied by a shaking of the ground and of buildings. A red-tinted cloud was for a long time visible in the east. The directors of the Observatory suppose the phenomenon was caused by an aerolite. Owing to the time that elapsed between the observation of the explosion and the report, the aerolite must have burst at a great distance from the earth." Reports conflict as to whether or not pieces of the meteorite have been found.

Buried Timber in Glacial Lake Beaches.

Mr. Ossian Guthrie, whose researches on the glacial drift of Chicago and a large region about the southern part of lake Michigan are well known, reports in the Chicago *Times-Herald* of Feb. 2d, 1896, the occurrence of two tree trunks of white oak in and beneath the Late Glacial beach gravel and sand of lake Warren, one being found eleven feet below the surface in an excavation at Thirty-ninth street and Forest avenue, and the other at Thirty-eighth street and Indiana avenue eight feet below the surface. The first mentioned was about two feet in diameter and was traced a distance of fifty feet. Pieces of board sawn from this tree were distributed by Mr. Guthrie to several geologists and museums. Fragments of trunks and branches of elm, willow, butternut, and black walnut, are also reported as found in the same beach deposit.

Coal Fields of Newfoundland.

Mr. James P. Howley, director of the Geological Survey of Newfoundland, in the Ottawa *Evening Journal* of Feb. 8th, 1896, describes the coal fields which are reached by the new railway, about 300 miles long, crossing the island from east to west. Ten coal seams are found in the area around the northern end of Grand lake, and one of these, 3½ feet thick, yields coal which, on being tested at St. John's, proves to be of superior quality. Near the west end of the railway, in the vicinity of St. George's bay, three coal seams, respectively 4 feet, 4½ feet, and 5¼ feet thick, are exposed by excavations; and it is stated that, with accompanying thinner layers, an aggregate thickness of 27 feet of coal is determined in that field, which has an extent, so far as yet ascertained, of five miles or more, with a width of at least two miles.

Erosion of the St. Croix Dalles.

Mr. Warren Upham, in a lecture March 18th, at Taylor's Falls, Minn., on "The St. Croix River before, during and after the Ice Age," attributed the erosion of the narrow but short gorges or cañons called the Upper and Lower Dalles, close below the villages of Taylor's Falls and St. Croix Falls on the opposite Minnesota and Wisconsin sides of the river, to the Aftonian and Wisconsin stages of the Glacial period. Previous to the Ice age it appears that a watershed of trappean and Upper Cambrian rocks there extended across the present valley. Five-sixths of the basin, lying above the Dalles, was probably drained during the Tertiary era by a watercourse leaving the present St. Croix valley near the mouth of the Sunrise river and running south and southwest to the Mississippi somewhere between Anoka and Minneapolis. This was the preglacial St. Croix. Below the Dalles was the preglacial Apple river, flowing to the Mississippi along the present lower course of the St. Croix river, where it is now expanded in the lake St. Croix. The channeling of the picturesque Dalles, which are the central attraction of the proposed Inter-State Park, seems chiefly attributable to an interglacial river of the Aftonian time of extensive retreat of the ice border in the upper Mississippi region: but these gorges have undergone further changes by Late Glacial and Postglacial stream erosion, and their walls of trap rock have been much riven by frost along vertical joint planes.

Glacial Drift Island in Barents Sea.

Kolguev island, having an area of about 2,000 square miles, and a maximum altitude of 250 feet, situated in Barents sea 130 miles southwest of Novaya Zemlya and about 50 miles distant from the nearest mainland of arctic Russia, is found by Mr. Trevor-Battye and Col. H. W. Feilden to consist wholly, so far as observable on the surface and in sections, of glacial and modified drift. Deposits of sand and gravel, with frequent boulders, extend in some places, notably on the highest plateau and in outlying hills, to maximum depths of about 80 feet. Under these stratified beds, the chief mass of Kolguev island is bluish gray clay, containing abundant stones and boulders, many of them glaciated, of all sizes to 15 feet in diameter. From the description of this boulder-clay it seems to be true till, for it rarely incloses any distinct layers of sand and gravel, and its boulders show no tendency to arrangement in horizontal lines. This large island lies just inside the border of the area assigned to the European ice-sheet on Prof. James Geikie's map, and it appears to be mainly or wholly a great marginal deposit of that ice-sheet. It is separated from Russia by a depth of water nowhere exceeding 30 fathoms. (*Q. J. G. S.*, vol. 52, pp. 52-65, Feb., 1896.)

S. Sekiya, born in 1855; died Jan. 9th, 1896.

In the principal departments of geology to which Japan has largely contributed, namely, volcanism and seismology, Prof. S. Sekiya, whose death, at the age of forty-one years, occurred on January 9th, had done highly valuable original work. Perhaps the topic of most general popular interest which he investigated, in collaboration with another Japanese, Y. Kikuchi, was the extraordinary and very destructive mud and dust eruption of Bandai-San on July 15th, 1888, whereby 166 houses were totally or partially destroyed and 461 persons lost their lives (Trans. Seismological Society of Japan, vol. XIII, 1890, pp. 139-222, with ten plates). Sekiya's geologic publications, both in Japanese and English, were many and important. A brief biographic notice of him, in the March *Geological Magazine*, probably written by John Milne, concludes as follows: "The construction of a model to show the motion of an earth particle at the time of an earthquake is an indication of his originality and ingenuity. By his influence and persuasive power he did much towards the distribution of seismographs throughout his own country, and the extension of a seismic survey which at the time of his death boasted of no less than 968 stations at which earth shakings are recorded. One thing in which he was interested, and in which he took part, were experiments to determine forms of construction most suitable for earthquake districts; and although he did not live to see the ultimate results of these investigations, he saw that earthquake effects had already been diminished and that in future the loss of life and property would be further minimized. His kindly disposition made him the friend of all who had the pleasure of his acquaintance, whilst the straightforward manner in which he never failed to express his ideas gained their admiration."

Philadelphia Academy of Natural Sciences.

At the meeting of Feb. 10th, Gen. Isaac J. Wistar called attention to the apparently capricious distribution of iron oxide as coloring matter in the rocks of the anthracite coal region. He said:

A section of Lykens valley, for example, shows a thick stratum of red shale below the Carboniferous series. It is overlain by thin green sandstones, the color of which is due to another oxide of the same metal. Upon this rests the thick masses of the Pottsville conglomerate, a white quartzite which shows no coloration from iron, except perhaps a slight external tinge on the enclosed quartz pebbles. Above the conglomerate we find intercalated among the sandstones of the Coal Measures sixteen coal seams of varying thickness of which the lowest three show a red ash, several above them a white ash, while the upper three return to a red or pink ash. Above the Coal Measures there are no signs of iron coloration until, in other localities, the Trias is reached where we find the red coloring as pronounced as in the Subcarboniferous shales.

These several strata cover a long period in geological history and exhibit the following phenomena:—During the red shale period the presence of iron oxide was sufficient to give a high color to the entire deposits. During the still longer period of the conglomerate the available iron having been all distributed in the red shale did not appear at all, and the conglomerate beds show none. In the deposit of the three lowest seams a fresh supply of iron appears, enough to color their mineral constituents red. Then ensued a long series of coal seams containing little or no iron, to be followed by several red ash seams near the top of the series. There is then an entire absence of iron in sufficient quantity to color the rocks, until, in other localities, the Triassic period, when evidences of the universal distribution of iron oxide are more abundant than ever.

These facts appear to show several points during which the accessible supply of iron was exhausted by complete distribution in the strata under process of deposit with intermediate and subsequent periods during which new supplies appear from some source not yet clearly explained.

Prof. A. P. Brown continued the discussion and said:

It has been suggested by Russell that the red color of certain formations may have originated from the subaërial decay of iron-bearing rocks and the subsequent deposit of this material as sediment, forming the red rock. Such rocks as contain iron, especially limestone and the metamorphic schists, would weather in the atmosphere to reddish clays and during periods when denudation of the surface was not active, or when the land remained at constant level such weathered accumulations could form to considerable depths. A rise of land level would cause denudation of this accumulated red soil and result in its deposit elsewhere. The periods preceding the formation of the Mauch Chunk red shales and the New Red or Trias were such periods of quiescence and they were followed in the first case locally, and in the second generally, by elevation of land, causing denudation to be set up and accumulation of red clays to be formed.

As far as the ash of coal is concerned, it is probable that the color is due to the way in which pyrite is contained, either in the coal itself or in the slates adjoining. Coal containing separable pyrite would give white ash, while if the pyrite is intimately mixed in the coal the ash will be red.

The subject was further discussed by Messrs. Heilprin, Willcox, Goldsmith and Lyman.

A communication was read from Dr. Persifor Frazer regarding certain supposed new trap dykes in Chester county, Pennsylvania, described before the Academy by Mr. Theo. D. Rand.

Mr. Jos. Willcox and Prof. Angelo Heilprin commented on the evolutionary value of a collection of 308 recent and fossil Fulgurs from various localities and geological horizons presented to the Academy by the former, who claimed that about twenty-five species had been reduced by the presence of complete series of intermediate forms to three or four.

New York Academy of Sciences.

At the meeting of the section of geology and mineralogy of the New York Academy of Sciences, held March 16th, Prof. J. J. Stevenson in the chair, the first paper of the evening was presented by Mr. Heinrich Reis on "A visit to the bauxite mines of Georgia and Alabama." The speaker first outlined the occurence of bauxite in Europe and in the United States, illustrating his remarks by means of lantern slides. He then described his trip through the bauxite region of the states mentioned, using the same method of illustration and exhibiting a large series of specimens. Mr. Reis showed the association of bauxite with occasional beds of limonite and lignite and the frequent occurrences of white clays in association with the ore. In their geological relations nothing of moment was, however, brought to light that has not already been published by Dr. C. W. Hayes in his recent paper in the 16th Annual Report of the Director of the U. S. Geological Survey. In the discussion Mr. R. E. Dodge called attention to the close connection between the bauxite and the Tertiary peneplain of the region so that the ores are not found except at a point where the great fault lines of the region cut the Knox dolomite between 900 and 950 feet above tide as shown by Dr. Hayes. Prof. Kemp in discussion called attention to the close association of limonite and lignite with the bauxite and remarked upon the close parallel that exists between these deposits and the Siluro-Cambrian iron ores of the North. In the South we have hydrated oxide of aluminum, with subordinate limonite. In the north the iron oxide is in excess while the hydrated oxide of aluminum is present in the somewhat uncommon mineral gibbsite. He also remarked upon the existence of lignites at Brandon, Vt., and Mont Alto, Pa. While the limonites of the North have been in part derived from the sulphate of iron produced by decomposing pyrites, but little alumina seems to have been formed by the sulphuric acid which has also of necessity resulted. Prof. Kemp further remarked that a recent article in the *Engineering and Mining Journal* of March 14th stated that the gossan of the Royal gold mine near Talapoosa, Ga., extended a considerable distance below the present water line and he suggested that it perhaps indicated a recent depression which has brought the oxidized zone below the ground water.

The second paper of the evening was by Mr. R. E. Dodge on "The Cretaceous and Tertiary peneplains of eastern Tennessee," on the basis of observations accumulated during two summers' field work in the region under Dr. C. W. Hayes of the U. S. Geological Survey. The speaker described the geographic development since the Cretaceous period of the country lying west from Chattanooga and across the Sequatchie valley to the Mississippi river. By means of maps and sections Mr. Dodge set forth the geology of the old Cretaceous peneplain now forming the Cumberland plateau with a few monadnocks projecting above it; next the Tertiary peneplain that shows like a great shelf on each side of the river valley; and then the present river valleys and the plains to the west of the plateau region which are now being still further notched by the active streams. A map of the region that the speaker had prepared and colored so as to show the extent of each peneplain, or in other words the geographic development, was exhibited and commented upon. In discussion Prof. Stevenson remarked upon the high terraces that he had met along the Monongahela, Alleghany, Cheat, and New rivers in Pennsylvania and West Virginia. He referred to their uniform altitudes over wide areas and to their occurrences above the river terraces. He seems to favor, however, the view that they were wave cut terraces remaining from a period of submergence, but remarked that they were wonderfully well preserved for ones of ancient date.

The section then elected for the ensuing year the same officers that had held the last year, viz.: J. J. Stevenson, chairman, and J. F. Kemp, secretary. J. F. Kemp, Sec'y.

Geological Society of Washington.

At the regular meeting of this society, held on February 26, the following communications were presented:

Mr. W J McGee exhibited the geologic map of the state of New York which was recently printed by the U. S. Geological Survey for Prof. Hall the state geologist. Mr. McGee stated that the map had been in preparation for the last ten years and its preliminary draft was a compilation by Prof. Hall and himself in greater part from old data. Finding that these were very incomplete and unsatisfactory in many areas, new field work was begun and continued at intervals for several years. In the meanwhile a new base was compiled. The larger part of the field work was done by Mr. N. H. Darton of the U. S. Geological Survey. Dr. F. J. H. Merrill contributed data for Westchester, Putnam and New York counties, and Prof. J. F. Kemp mapped much of the region lying along the eastern side of the Adirondacks. Data for smaller areas were obtained from published or manuscript maps by Messrs. C. D. Walcott, T. N. Dale, J. M. Clarke, W. M. Davis, W. B. Dwight, and others.

"*Notes on the Geology of the Black Hills of Dakota*" were presented by Mr. N. H. Darton. The region was visited last autum for a study of the outcrops of the Dakota sandstones and the associated formations in connection with an investigation by the Geological Survey of the artesian waters of the Dakotas. There was first described a detailed section which had been carefully measured from the base of the Potsdam to the White River Miocene formation, along a line passing through Rapid City to the Bad lands. The thicknesses of the upper Cretaceous members in this section have since been most satisfactory verified by the deep-well boring on the Rosebud Indian reservation. The salient features of the general stratigraphy were pointed out and the alleged unconformities in the Juratrias formations were discussed. Attention was called to a well defined peneplain now represented by the eastern "hog back" foot hills of which the very even crest lines are at an altitude very nearly 4,000 feet above sea level for over 100 miles. Diagrams were exhibited of an interesting laccolite west of Tilford and the structure of the Bear Butte and Warren Peaks eruptive areas were described. Some incidental observations in the nucleal region of the Hills brought to light some important details of stratigraphy of the Algonkian beds, and some examples illustrating the development of schistosity in the vicinity both of granitic and younger eruptives.

In the discussion which followed this paper, Mr. M. R. Campbell alluded to the close similarity between the relations of the even crest lines of the "hog back" ranges described by Mr. Darton, and the Appalachian ridges, and endorsed the view that they are similarly the remnants of peneplains preserved by the harder rocks.

Mr. F. W. Crosby presented a paper entitled "*The sea mills of Cephalonia*." These mills are run by sea water which flows into fissures with considerable velocity. The origin of these fissures and the conditions which enabled the sea water to sink into them below the level of the sea have been the subjects of popular speculation for many years, but they appear to have atracted but little attention among geologists. Mr. Crosby then quoted a paper by his son, Prof. W. O. Crosby, in which the mechanism of the phenomena was discussed and a hypothesis offered to account for it.

A paper on the "*Stratigraphy at Slate Springs, California*" was read by Mr. Lindgren.

At the 45th meeting of this society held on March 11, Prest. S. F. Emmons, in the chair, two papers were read, one by Mr. Bailey Willis on "Evidences of Ancient Shores," and the other by Mr. David White on the "Thickness and Equivalence of some Basal Coal Measures Sections along the Eastern Margin of the Appalachian Basin."

Mr. Willis discussed the evidences of ancient shores with reference to their position, trend, and duration. Five classes of evidence were enumerated; namely, (1) overlap or unconformity, (2) suncracks, trails, or ripple-marks, (3) coarser deposits, (4) thicker deposits, and (5) synclines of deposition.

Any point on an unconformity marks with precision a point on some shore line at some instant of time, but as the outcrop of an unconformity cannot be assumed to be parallel to the former shore line, this evidence does not define the trend of the ancient shore, and as the shore was in transit its duration was transient.

In contrast with this conclusion was placed that derived from thick deposits of shales such as are formed by the delivery of a large volume of sediment concentrated at the mouth of a river draining an extensive watershed. These conditions result in the accumulation of a lenticular formation which thickens rapidly from the shore and thins more gradually seaward. When the thickness of the shale is pronounced, the duration of the conditions was probably long continued. Such evidence therefore indicates the approximate position, general trend, and long duration of the ancient shore.

In folded regions such conditions of deposition as have just been described determine the position of synclines of the greatest magnitude, the synclines of deposition. Such folds are further characterized by a very steep dip on the shoreward side and by the stratigraphy, which should include a massive bed of shale. When sufficiently characteristic to be recognized, the syncline of deposition thus becomes an evidence of proximation to shore, with axis parallel to its general trend ; the infolded strata may also indicate the prolonged duration of the neighboring shore line.

Thus the causal relation which exists between sedimentation and folding is appealed to to aid in the determination of ancient shore lines.

Mr. David White communicated informally some preliminary results of his recent work under instructions from the director of the U. S. Geol. Survey in the stratigraphic paleontology of the lower portion of the Carboniferous proper (Mesocarboniferous) and of the Pottsville series in particular. The speaker exhibited columnar sections of the series near Coxton, Pottsville and Tremont, Pa.; Piedmont, the New river and the Tug river, W. Va.; Soddy, Tenn.: and in the Warrior coalfield, Ala., on which were indicated, the stratigraphic position and vertical extent of the paleontologic divisions of the Pottsville series.

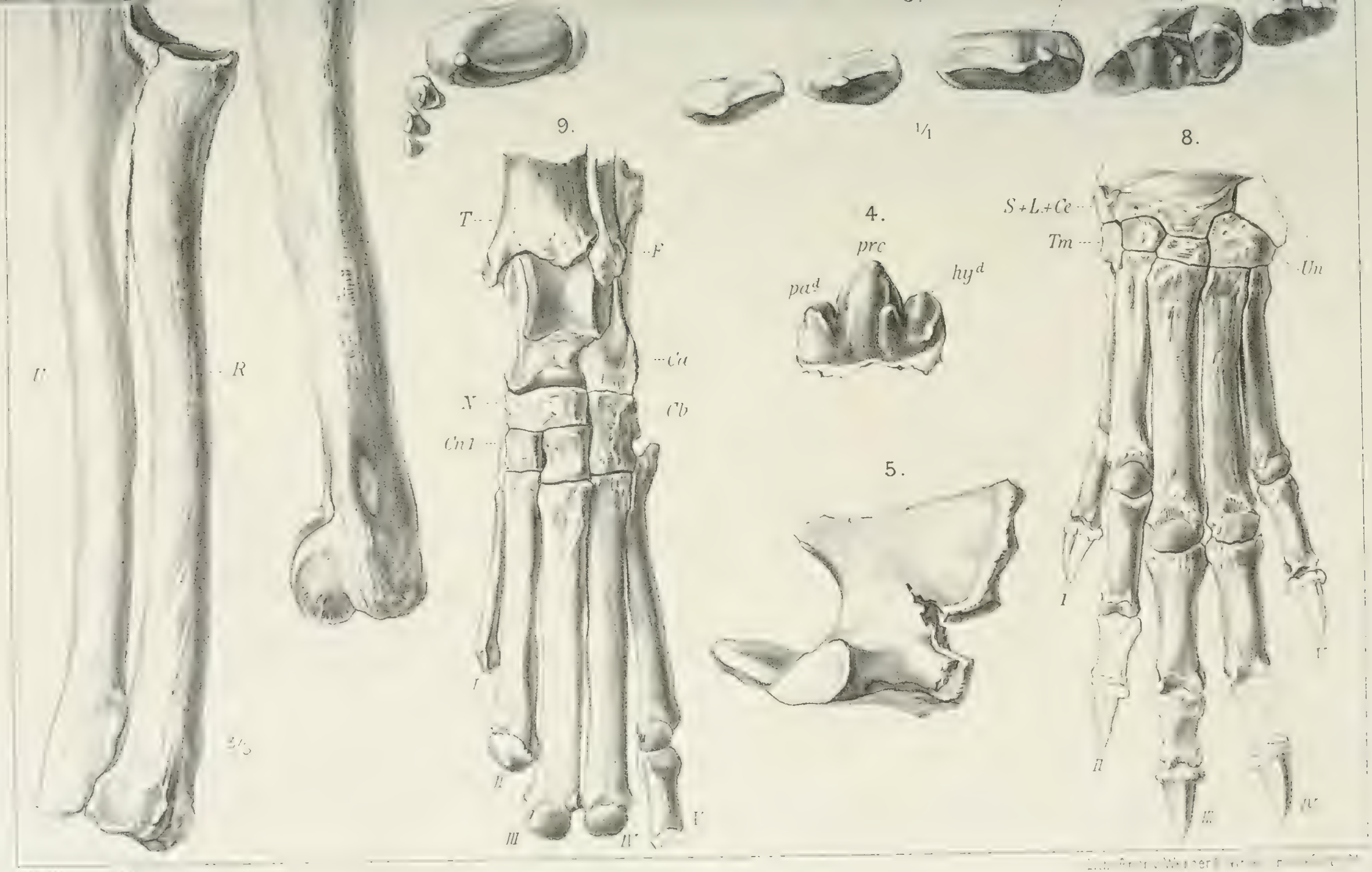
Although the plant collections are often fragmentary or represent, in some regions, only one or more levels in some of the sections, the individual collections are generally clearly referable to one of the floral divisions,—viz., Pocahontas, Horsepen, and Sewanee, in ascending order,—suggested in the author's preliminary paper on the New River section at the Baltimore meeting of the Geological Society of America, while the approximate level in that division is also frequently indicated with considerable reliability, as is shown by stratigraphic verification. The limits of these floral divisions, now fairly well determined in the New River section, have been traced somewhat precisely through the Flat Top-Tug River section, where the total thickness is seen to expand far beyond the 1700 feet of the New River section, while material from two localities in the Big Stone Gap, Va., region shows the presence of a flora belonging to the Sewanee division, at a probable hight of 2300 feet above the base of the series, denoting, perhaps, the maximum thickness of the series near this point in the central Appalachian trough.

Special importance attaches to the author's conclusions that the inclusion of the lower part of the "Walden sandstone" of Hayes, represented by the "Second series" of Safford, in the upper or Sewanee division of the Pottsville series is fully demonstrated by the fossils of the West Virginia and the type (Pottsville) sections, while the underlying terranes, including the "Millstone grit" and upper part, at least, of the "Sub-conglomerate" of Safford or the "Lookout sandstone" of Hayes are referable to the Horsepen division. Such scanty fossil material from Alabama as is available indicates that in the Warrior coalfield the Warrior and Black Creek seams belong in the Horsepen division, while the Newcastle and Pratt seams appear to fall within, certainly not above, the Sewanee division, though the Pratt Seam is said to be about 1800 feet above the base of the series. Such a correlation necessitates placing the boundary of the lower productive Coal Measures many hundreds of feet higher in Tennessee and Alabama than has yet been done by the geologists in those states. It also follows that the Lykens Valley coals in Pennsylvania, the New River and Pocahontas coals of West Virginia, as well as the valuable coking coals of Tennessee and Alabama. all seem to fall within the limits of the Pottsville series.

Attention was also called to the absence of the Pocahontas and even the Horsepen division floras in some of the thin sections of the series in this basin, apparently disproving the generally accepted view that the difference between the thick and the thin sections is wholly a question of expansion.

W. F. Morsell.


1.
2.
3/5
6.
7.



TEMNOCYON FEROX *Eyerman.*

THE

AMERICAN GEOLOGIST.

Vol. XVII. MAY, 1896. No. 5.

THE GENUS TEMNOCYON AND A NEW SPECIES THEREOF AND THE NEW GENUS HYPOTEMNODON, FROM THE JOHN DAY MIOCENE OF OREGON.

By John Eyerman, F. Z. S., F. G. S. A., Easton, Pa.

(Plate XI.)

The Princeton Scientific Expedition of 1889 confined its work to the John Day region of Oregon; this expedition being one for the no mere purpose, solely, of collecting, but being formed upon a scientific basis, as is characteristic of these expeditions, it secured not only an enormous amount of material, including some complete skeletons, but also undertook a geological survey of the country traversed, and particularly where the fossils were *in situ*, with the gratifying result of proving or disproving some heretofore debatable points. This wild and almost impassable region, too, is all the more interesting as exhibiting the manifestations of volcanic activity and the work of atmospheric erosion on a truly magnificent scale. The principal points at which the greater part of the work was accomplished were the Middle fork, Cottonwood creek, Rudio creek, the "Big Basin" of the John Day, Haystack valley and Bridge creek.

The mammalian fauna of the John Day is represented by many genera of Rodentia, Carnivora, Perissodactyla and Artiodactyla. Of the Canidæ it is impossible to give even an approximate idea of the number of species so far obtained from this horizon. Professor Cope in his one published book on "The Tertiary Vertebrata" has described species from twelve genera; suffice to say, however, that their abundance and variety are much greater than from the next lower horizon, the White River. The structural advance, too, over the preceding or next lower horizon is also very marked.

It again gives me much pleasure to acknowledge my great indebtedness to Dr. W. B. Scott for his assistance and advice in preparing this comparative memoir, and for the free use of material from the Princeton museum.

TEMNOCYON, Cope.

Talon of the inferior sectorial is trenchant. Inferior second molar has trenchant crown and *no internal cusps.*

Dental formula $i\frac{2}{3}$ $c\frac{1}{1}$ $p\frac{4}{4}$ $m\frac{2}{3}$.

The type consists of portions of three individuals, two rami and the anterior portion of the skull, to which Cope (No. 1, p. 903) has given the name *T. altigenis.*

Temnocyon ferox Eyerman (No. 2. p. 320).

Larger than the type species. Cranium unusually well developed and considerably longer, but of less transverse diameter than the type species. Palate vaulted. Small antero-posterior development of the true molars. Superior premolars equal in antero-posterior diameter and greater in transverse diameter than in the type. Unusual development of cingulum on the first true molar and the unusual position of $\underline{m.2}$ with reference to $\underline{m.1}$. In the inferior dentition the weak development of $\overline{p.4}$ in height, and the antero-posterior development as compared with the transverse. The small size of the metaconid of $\overline{m.1}$ and the regular contour of its crown. And finally the extraordinary development of the pollex and hallux.

Description.—The unusual elongation of the cranium (fig. 1) is perhaps best illustrated by comparing the length thereof with the transverse diameter of the palate in the type species and *T. ferox.* The diameter of the palate is one-fifth the length of the skull, whereas in the type (*T. altigenis*) this diameter is less than one-third the length, or in other words the length of the skull of *T. ferox* is nearly one and three quarter times greater than that of *T. altigenis*, yet the diameter of the palate of the former (58 mm.) is less than that of the latter species (65 mm.). This comparison applies also to *T. wallovianus* Cope (No. 1, p. 905) which, although a smaller species than the type itself, still has a slightly greater palate diameter than even *T. ferox.*

In the living *C. familiaris* of equal size we find this diameter equivalent to the proportions exhibited in *T. altigenis.* The mandibular ramus of *T. ferox* in height or width does not vary with the same irregularity as in the type species, in the former measuring 37 mm. in width or height from under $\overline{\text{p.1}}$ to $\overline{\text{m.1}}$, and in the type 25 mm. at $\overline{\text{p.1}}$ to 30 at $\overline{\text{m.1}}$. The base of $\overline{\text{m.2}}$ is some 5 mm. above the base of $\overline{\text{m.1}}$, but in the type it is in the same line with $\overline{\text{m.2}}$. From these measurements it would seem that the ramus of *T. ferox* is proportionately not so great as the size of the species would indicate.

Note. Comparisons with Cope's *T. coryphæus* (No. 1, p. 906) must be eliminated from this present part and will be hereafter described under the new genus *Hypotemnodon* (No. 2, p. 321).

MEASUREMENTS. (*T. ferox.*)

Width across the presp. pterog.	25 mm.	
the frontal	59	
between orbits (least)	46	
" bases of canines	18	*T. altigenis* 18 mm.
" apices of paraocc.	65	
foramen magnum	30	
occiput (above)	50	
between ms 1	24	*T. altigenis* 38 mm.
of palate	58	" 65
Length of pm-m series	94	" 77
true molars	26	" 21
Total length	266	
of dentition	128	*T. altigenis* 97

The Dentition.—In the superior dentition of *T. ferox* (fig. 2) the largest incisor is more or less rounded at the apex and not so acutely pointed, the base development more robust and the tooth more erect than in the type species in which the tooth curves backward almost to the point of joining the canine. The canines are about twice the size of those of the type, the bases more robust and the apex less pointed.

The first and second premolars are simple teeth varying in size in the several species, although this variation is irregular and does not conform to the variation in size of the craniums.

Comparing the diameters of both p. 1 and p. 2 we find first, that in p. 1 the transverse and antero-posterior diameters are twice those in the type species, while in p. 2 the antero-posterior is less than twice and the transverse diameter equal to that of the type. Again, p. 2 of *T. wallovianus* (the smallest species of the three) has a greater antero-posterior diameter than *T. altigenis*, and further, in p. 1 of the same species the diameters are slightly greater than and in the still smaller species, *T. josephi* (No. 1, p. 912), nearly equal those in the type species. The contour of the crown of p. 2 in *T. ferox* is of a regular rectangular shape and compressed transversely, while in *T. altigenis* the external and internal lines are so formed as to produce nearly an L-shape, the point of divergence being the cone from which the anterior edge comes forward and the posterior outward. P. 3 exhibits the same irregular variation in size; in *T. ferox*, it has, perhaps, a slightly greater antero-posterior diameter and the transverse diameter is one-half that of the antero-posterior, while in the type this diameter is less than one-third the antero-posterior; *T. altigenis* and *T. wallovianus* have nearly the same measurements, indicating for the smallest species the greatest relative development. In *T. ferox* a minute cusp (1.5 mm.) is developed on this tooth, but is absent in the other species. *T. ferox* and *T. wallovianus* have their greatest transverse diameter at the posterior, while in *T. altigenis* it is greatest at the anterior. This is due in a measure to the position of the main cone, rising as it does, at the anterior, in the latter species and at the centre, in the former. The irregular variations in p. 4 do not conform to those of the preceding premolars. In *T. ferox* and *T. altigenis* the diameters across the deutero- and tritocones are (and in *T. wallovianus*, nearly) equal. The proto-tritocone diameter is slightly greater in the type species and the transverse or proto-deuterocone diameters are equal in both *T. altigenis* and *T. wallovianus* and one-fourth greater in *T. ferox*. From this may be deduced the fact that the largest species has the least (or smallest) development. As mentioned above, the smallest species (of the three), *T. wallovianus*, seems to have, proportionately, the greatest development in the premolar series. In the species under consideration, *T. ferox*, the protocone has the greatest height, the anterior edge inclines backward to a greater extent and on the whole is more compressed laterally than in the type species; this cone rises from the centre of the crown and, in the type species, anterior thereto. The deuterocone is well developed only in *T. ferox*, in the type being very minute and placed upon the edge of the crown; nor is there the deep groove or valley separating it from the protocone as in *T. ferox* and *T. wallovianus*. A minute incipient cone is present only in the former species. The tritocone is more or less flattened in *T. ferox*, but in the type shows a sharper and more marked cutting structure, the surface being highest near the protocone. In *T. ferox* the surface is nearly horizontal.

The first superior molar in *T. ferox* has a very strong cingulum on both the external and (particularly) the internal edges. In the other species, however, this development is much less marked. The transverse diameter is in all the species very considerably greater than the antero-posterior. There is a groove between the paracone and the metacone in the several species, being greatest and deepest in the largest. In this species, too, the two cones show greater lateral compression. The protocone is greatest in *T. ferox* and rises directly internal to the groove separating the external cones, whereas in the type species it is nearly internal to the paracone. A groove or valley separates this cone from the external ones and is deepest and widest in *T. ferox* and in this species the cone is more regularly rounded and of a more pyramidal shape than in the two smaller ones. A small cone is present at the internal posterior edge of this groove *only* in *T. ferox*. The position of $\underline{\text{m.2}}$ forms a characteristic feature of this species. In the other Temnocyons the external surface of this tooth may be said to form a regular and continuous line with the preceding molar, but here the position of this molar is such as to make it join $\underline{\text{m.1}}$ (for they are close together) directly posterior to the internal base of the metacone, and the posterior edge of this molar forms, with the external edge of $\underline{\text{m.2}}$, a regular right angle. The two molars are placed side by side and close together throughout, whereas in the type species, they touch only at the external edge. The antero-posterior diameters both external and internal are the same in *T. ferox*, but in the type species the diameter of the former is greater than the latter (or internal). The para-and metacones are, however, proportionately better developed in the type, the metacone being quite small in *T. ferox.* In all cases the paracone is the larger. The protocone of *ferox* is more pyramidal and robust and is surrounded by a greater cingulum. The transverse diameter of the anterior portion is equal in both species, but the diameter of the posterior is less in the type, due to the inward posterior inclination of the external edge. Again the anterior and posterior edges are parallel in *T. ferox*, but in the type species the anterior edge converges toward the internal, making thereby, as stated above, the external diameter greater than the internal.

In the inferior dentition of *T. altigenis* the incisors, canines, and first premolar and in *T. ferox* (fig. 3) part of the incisors and the first premolar are missing. In the former species the dentition from $\overline{\text{p. 2}}$ to $\overline{\text{m. 2}}$ measures 66 mm. and in the latter 90 mm. The canines have an antero-posterior diameter of 19 mm., transverse 10 mm., and a height of 38 mm. They curve backward and are placed external to a line drawn along the external bases of the $\overline{\text{p. m-m}}$ series. $\overline{\text{P. 2}}$ is a simple tooth of equal height in both species, but one-third greater in antero-posterior diameter and one-fourth in transverse than in the type; this difference is not due to a greater development of the cone in *T. ferox*, but to a more elongated crown, giving rise to a minute heel. $\overline{\text{P. 3}}$ is also a simple tooth of proportionately slightly greater development over the type tooth. $\overline{\text{P. 4}}$ of *T. ferox* has a greater transverse diameter over the antero-posterior than in the type and is one-fifth greater in length and one-half in width. The height of the protoconid is the same in both species and hence is proportionately somewhat greater in height and is more distinctly separated from the latter cone than in *ferox.* A minute cusp (of rather rare occurrence) is formed on the talon or heel, but is absent in the type species. This cusp is separated from the protoconid by a sharp groove. The contour of the crown of $\overline{\text{m. 1}}$ is more regular, the centres not being compressed and there is a greater upward curve under the main cone. The paraconid has the usual sharp elongated surface pointing inward; the proportionate heights, if compared with those of the protoconid, indicate a greater development in *T. ferox.*

The hypoconid is equally well developed in both, but in the type has a sharp elongated surface, which in *ferox*, is pointed toward the centre giving rise to a pyramidal structure. The groove between this cone and the protoconid is deeper in the type. The protoconid is separated from the para- and hypoconids by a well defined groove. The height of this cone is 15 mm., and in the type 11 mm. In *T. ferox* the metaconid rises from the side of the protoconid, but in the type species from the base thereof. On account of the irregular contour of the crown of this tooth in the type species the posterior cone is in a direct line drawn through the paraconid, while in *T. ferox*, which has a regular parallellogram-shaped crown, the hypoconid is directly posterior to the former. There is a minute entoconid at the posterior edge, which is, however, absent in the type species.

The antero-posterior diameter of $\overline{\text{m. 2}}$ is nearly equal in both species and the transverse only one-fourth greater in *T. ferox*, the height of the protoconid is very little greater and the apex thereof is less acutely pointed and hence the diameter of the base is greater in this species; the hypoconid has the same height in both species and, like the protoconid, is more acute in the type; the internal cusps are absent in both. A cingulum is developed in *T. ferox*, but in the type is very rudimentary, if developed at all.

The Vertebral Column.—The axis (fig. 5) is longer and more robust, and the odontoid process somewhat shorter than in the living species. The diameter of the concavity above the articular surface for the atlas is slightly greater and not so sharply curved, and the transverse diameter is greater at the posterior; the lower part of this surface does not project below the lower line of the bone, the transverse processes and the zygapophyses are stronger and of greater width; the vertebrarterial foramen is placed nearly at the base and is more elongated. The first thoracic vertebra measures 34 mm. across the anterior and 36 mm. across the posterior zygapophyses. The lumbar vertebræ differ somewhat from the usual shape found in recent *Canidæ*; the antero-posterior diameter of the first lumbar being somewhat greater than the transverse, but in the seventh the former diameter is one-half that of the latter; the transverse processes are here unusually robust, but they do not curve forward to so great an extent, nor are they so pointed; the longitudinal diameter is considerably greater than in *C. familiaris* of equal size; the spinous process is weakly developed and the diameter across the posterior zygapophyses is greater than across the anterior. The antero-posterior diameter of the sacrum is less than the transverse and the anterior portion considerably more transversely extended than the posterior; the anterior processes are rather narrow and elongate, not so robust as in the living species. The diameter is 63 mm.; the spinous process is undeveloped and the zygapophyses very poorly so; there is on the whole very little variation in transverse diameter throughout the bone. Compared with the development of the other vertebræ, the caudals are more robust and of greater relative length; the transverse diameter of the first caudal is greater than that of the sacrum; its length is 70 mm.

In *T. ferox*, the scapula differs somewhat from the usual shape in most *Canidæ*. The greatest vertical length is from the coracoid to the posterior upper edge and not along the spine, as in *C. familiaris;* the spine, which measures 170 mm., is not so well developed, falling short of the supra-scapular border by quite 20 mm; on the lower end it is nearest the posterior border and not just above the glenoid. This cavity is rather shallow. The glenoid and the coracoid borders, just above the distal, curve inward toward the spine and measure from edge to edge, at this point, only 35 mm., whereas in the living species of the same size this diameter is 45 mm. The prescapular fossa curves backward and inward and measures at its greatest diameter 38 mm; the postscapular curves inward and has a diameter of 48 mm.

The Fore Limb.—The limb bones of *T. altigenis* are not preserved. The shaft of the humerus (fig. 6) is rather slender, with the anterior and posterior faces quite erect, not with the usual curvature; on account of this erect position of the shaft, the proximal end is curved backward rather more sharply than in the living species, in which the entire shaft shows an easy backward curve; the anconeal fossa is not sufficiently deep to form a vacuity in the bone; the epicondylar foramen is present and fairly well developed. The shaft above the trochlea is very flat, the *brachialus anticus* or ridge not curving forward to join the internal edge of the trochlea as in *C. familiaris.* The proximal end is proportionately not so well developed as the distal; the head is rather more elliptical than spherical and does not overlap the shaft, neither is it proportionately so large. The external (internal to the body) side does not curve inward toward the bicipital groove but comes to a point and forms more of a ridge, and, hence, the groove has greater width and is not so sharply deepened on the external or tuberosity side; the distal end measures 45 mm. across and is of normal development; the transverse diameter of the articular surface for the ulna is 13 mm. and for the radius 20 mm; the vertical diameters are less and not in proportion to the development of the end as a whole; the groove between the trochlea is rather shallow; the external condyle is weakly and the internal very strongly developed. The ulna (fig. 7) is considerably shortened, for, while the humerus is nearly equal in size to that of *C. familiaris*, the ulna is some 35 mm. shorter than that in the same *C. familiaris.* The shaft is slender and compressed throughout, especially just below the sigmoid, and the transverse diameter at this point is one-third that in the living species; neither does it describe that easy curve usually developed, but curves sharply backward and upward from the sigmoid cavity. The apex of the olecranon is nearly flat and from this point to the beak of the bone is considerably broader, with less sharp forward inclination; the coronoid process is well developed. Directly under the beak the diameter of the sigmoid cavity is 26 mm. or of more than normal development, but in depth not so great as in the living species. The articulation of the humerus is principally upon the sigmoid, like that in the smaller species, *C. aureus*, a second internal articular surface not being developed. The transverse diameter of the bone at this point is very narrow. In the living species the compression of the upper half of the bone is transverse; in the species under consideration, however, it is antero-posterior; the lower half of the shaft becomes more cylindrical as it approaches the distal end, the diameter at this point being equal in both species. Furthermore the shaft from a point below the cavity, has a very regular curve more like that in *C. aureus*. The distal extremity is less external to the radius, being more posterior thereto and the styloid process is weakly developed.

The radius (fig. 7) in size bears the same relation to the living species as the ulna; the upper one-half of the shaft is transversely compressed, while in the living species this compression is uniformly antero-posterior. The head has normal development and is very regularly shaped, particularly at the edges. On account of the transverse compression of the shaft, the head projects very considerably beyond and over the internal shaft line and is placed directly anterior to the coronoid of the ulna and not partly external; this end of the shaft does not show the usual tuberosities. The distal end extends somewhat below that of the ulna (the reverse of *C. familiaris*) and rather more anterior than internal to the ulna; the articular surface for the carpus is considerably reduced, hardly attaining one-half the normal size.

The manus (fig. 8) is broad and somewhat shortened. The transverse diameter of the carpus is equal to that in the living *C. familiaris* of equal size, but the length from the carpals to the phalanges is about 150 mm. or one-fifth shorter than in the above living species, in which the carpus is of the same diameter as that of *T. ferox.* This difference in length is due to the unusually short metacarpals III and IV. The scaphoid, lunar and central are coalesced and have a regular curved superior and irregular inferior surface; the greatest vertical diameter is over the magnum; there is a very slight articulation with the upper surface of the cuneiform, which bone is more regularly shaped than in *Canis*, neither is it so large nor does it articulate partly upon metacarpal V, but entirely upon the unciform; above the trapezium the bone is unusually robust. The trapezium articulates to considerable extent upon the side of the second metacarpal. It is very regular in shape and has its vertical diameter greater than the transverse. The reverse is true of the trapezoid, this bone having a plane inferior surface and not curving upward toward the trapezium. The magnum is rather transversely flattened and in consequence has a proportionately less diameter than *C. familiaris* and it articulates but very slightly upon the side of the second metacarpal. The unciform is of regular shape, with generally flat edges, and articulating upon metacarpals IV and V; the bone not only covers the fifth metacarpal but projects beyond it on the external side. In the metacarpals an interesting feature is the presence of an unusually well-developed pollex, which has the extraordinary length of 45 mm., or over one-half the length of the third metacarpal. As is usual it articulates in a different plane from metacarpals II-IV. The second metacarpal is proportionately shortened. The third and fourth are of normal size. The fifth is somewhat shorter than in the living species and contrary to the usual method articulates in a different plane from metacarpals II-IV, and more in a plane with metacarpal I.

The Pelvic Girdle.—The pelvis is not so robustly developed as in the living species, neither is the width across the supra-iliac border so expanded, being more or less compressed and measuring 67 mm; the innominate bone, with the exception of the diameter just above the acetabulum, is rather more slender. The acetabular and pubic borders are more or less parallel and do not curve toward each other, as they approach the acetabulum. The crest of the ilium is less curved, the diameter somewhat less and from the acetabulum to the pubic symphysis it is rather more elongate and narrow than in the living species; the symphysis of the pubis is narrow. The iliac surface from the acetabulum to the crest measures 91 mm.

The Hind Limb.—The length of the femur is 247 mm. A vertical line being drawn from the internal edge upward will pass through the middle of the notch between the head and the trochanter, whereas in the living *C. familiaris* this line in the same direction will pass through the middle of the head, the bone curving inward to a greater extent as it reaches the head, which must therefore be more defined; this is caused by the almost vertical external edge in *T. ferox* and by the inward curve of the bone in the living species. The femur, therefore, in the former species curves inward only, and in the latter the external edge outward and the internal edge inward; the greater trochanter does not project beyond the shaft line; the notch which forms the neck between the head and the trochanter is rather wide; the diameter of the head is 22 mm. and that of the neck 19 mm., both proportionately somewhat less than in the living species; the distal end is unfortunately badly contorted, but measures about 43 mm., the shaft here inclining backward.

The tibia and fibula have not been separated from the matrix, but apparently exhibit the same proportions as shown in the fore limb; the distal extremity of the former is proportionately of less diameter and the articular surface for the astragalus is considerably less than in the living *C. familiaris;* the bone is prolonged at its internal side, forming the internal malleolus, which is however not so well developed and does not project so much beyond the astragalus. The fibula articulates to a greater extent upon the anterior lateral surface of the astragalus, this being due to the very strong outward position of the external surface of the astragalus, as it approaches the posterior.

The tarsal bones (fig. 9), with the exception of the calcaneum and astragalus, are very regularly formed with squared edges and flattened surfaces; in this latter bone the articular surface for the tibia is rather narrow, and, viewed in an upright position, articulation with the tibia is nearer the proximal end of the astragalus. The bone when viewed directly from the front will show the two sides, and particularly the external more exposed, the articulating surface for the fibula being more anterior than in the living species. The calcaneum is of the usual shape, perhaps proportionately somewhat more strongly developed in length, the width however being of normal size. The navicular is elongate and narrow, the greater axis being horizontal; it articulates almost entirely upon the two cuneiforms. There is not the usual upward internal extension covering the internal edge of the astragalus as in the living species.

The cuboid is also elongate and narrow, its greater axis being, however, vertical; it has the same measurements as the navicular, but in reverse position. It does not articulate upon the external edge of the internal cuneiform and only very slightly upon the fifth metatarsal, the articulation being lateral. In *C. familiaris*, we find this bone articulating upon quite two-thirds of the surface of the fifth metatarsal. The cuneiform bones when viewed from the front show regular flat edges and form nearly perfect squares: the difference in size between the internal and middle bones is not so great as in the living species. In the specimen under consideration only the first phalanges of digits I–IV are preserved and the first and second of digit V. The most strikingly characteristic feature of the foot is the very extraordinary development of the hallux, the first or uppermost phalanx having a length of 40 mm., about one-half the length of the first phalanx of the median digit; it also articulates in a different plane (as is generally the case) from digits II–IV: the bone is slender and cylindrical and the lower end curves inward toward the second digit. The second is slightly more robust than the fourth and has a flat upper articular surface with squared edges and does not, as in the living species, curve away from the median; this latter is of the same length as the fourth, but more robust, with its internal side curving toward No. II. The fifth articulates in a different plane from those of III and IV and from that of the same digit in *C. familiaris* and extends considerably above the line between the cuboid and the fourth, articulating upon the lateral surface of the former; it is slender and curves away from the cuboid to a greater extent and the lower one-half is somewhat more separated from No. IV than in *C. familiaris.* The second phalanx is present and measures 22 mm.

Canis familiaris of approximately the same size as *Temnocyon ferox* of about 75 cm. in height has been taken for comparison with the latter, as has been seen above, for in many respects the latter species approaches nearer this species of *Temnocyon.* We have noticed that the body of *T. ferox* is perhaps somewhat longer, with more elongated cranium, and that the limbs are shorter, this shortening not occurring throughout the entire limb but principally in the radius and ulna of the fore- and the tibia and fibula of the hind-limb. Then too another very marked difference is the unusual development of the pollex and hallux.

Whether *T. josephi* and *T. wallovianus* are true Temnocyons or whether they should be removed to the new genus *Hypotemnodon*, as hereafter described, can only be determined when the mandibles of these species are discovered, at present only the upper jaw being at hand.

Comparison with Daphænus, Leidy.

In the genus *Daphænus* the teeth closely resemble *Canis*, but with three superior true molars. Femur has a third trochanter. Feet plantigrade and pentadactylate. Distal end of humerus with a foramen. Auditory bullæ apparently in two chambers, but if so the posterior one is not ossified and the periotic is exposed. Genus has dentition like the dog, with limbs more like the bear.

Dr. Scott (No. 5, p. 211) says, "The White River dogs with three upper molars are quite different from the true *Amphicyons* (No. 3, p. 219) and for these the name originally given them by Leidy, *Daphænus*, should be revived."

Temnocyon resembles the White River *Daphænus* in many respects, as will be seen later on, and differs in not having a third superior true molar; in the trenchant talon of $\overline{\text{m. 1}}$; the absence of internal cusps on $\overline{\text{m. 2}}$ and in having very much less expanded zygomas. Other characteristic features of *Daphænus* cannot be compared with *Temnocyon* on account of the poor preservation of these parts in the latter genus. In all cases the species used for comparison is Cope's *D.* (*Canis galecynus*) *hartshornianus.*

Temnocyon exhibits a very much more elongated and relatively more compressed skull than the White River genus. This is best illustrated by the following: The length of *T. ferox* from the line of the least diameter of the frontal to the posterior crest of the supra-occipital is 111 mm., and in *Daphænus* 72 mm. The greatest width of the parietal in the former is 70 mm. and in the latter 45 mm. From the parietal to the nasal the diameters are considerably less diminished than in *Daphænus*, and the molar, as might be expected, is more prominent in this latter species. The parietal is considerably more rounded in *T. ferox*; the crest of the supra-occipital is much narrowed and compressed and is carried high above the parietal, forming a narrow elongated ridge, this being due in a great measure to the greater rounded backward and downward curve of the parietal.

In $\underline{\text{p. 4}}$ the external edge of the crown inclines inward and forward and the entire form is essentially like that of the type of *Temnocyon.* The development of the cones is proportionately greater in the larger species, there is, however, a compression at the anterior edge between the proto- and deuterocones, which is not present in the type nor in *T. wallovianus*, but is developed in *T. ferox* and in *T. josephi.* The deuterocone (which in *T. ferox* is posterior) is in both *Daphænus* and *T. altigenis* anterior to the centre, and hence the declivity is sharper in these two species. In fact in all points both these two species agree very closely. The antero-posterior diameters are respectively 15 mm. and 20 mm., and the transverse are proportionate.

The contour of the crown of m.1 is essentially the same in both species with the following exceptions: the external edge of the crown is not compressed as in *Temnocyon*, neither is there a compression at the anterior and posterior of the tooth in both these species as in *T. ferox;* the antero-posterior diameters are, *T. altigenis* 14 mm, *Daphænus* 10 mm; the development of the para- and metacones is proportionate to this scale; the protocone, however, is perhaps equally as well developed in both, in the type being somewhat more pyramidal; in *Temnocyon* this cone is placed anterior to a line drawn through the groove between the external cones, but in *Daphænus* is directly opposite this groove; nor is the valley or groove separating this cone from the external ones so broad as in *Temnocyon.*

The contour of the crown of m.2 is almost identical with that of *T. altigenis* and its position with reference to m.1 is similar, but in this respect it differs, as does the type species, from the position in *T. ferox*, where, as noticed above, the tooth is set back from the external edge line of the preceding crowns and placed midway between the external and internal edges of m. 1. M.2 does not decrease with proportionate regularity, for in m.1 the antero-posterior diameter in *Daphænus* is about four-fifths that in *T. altigenis*, whereas in m.2 this diameter, in the former species, is about one-half that in the latter. The external cones are pyramidal, the metacone is nearly equal in size in both; the paracone is proportionately less in height in *Daphænus.* The protocone in both is rather an obtuse pyramid. The cingulum appears stronger in *Daphænus.*

M.3 is present in *Daphænus*, occupying the same position to m.2 as in *T. ferox* m.2 does to m.1, *i. e.*, it is placed back from the external crown line of the dentition and midway between the external and internal edges of m. 1. Its crown is nearly flat and does not show tuberculation very distinctly; the antero-posterior diameter is 3 mm. and the transverse 6 mm.

In the inferior dentition of *Daphænus* there are available for comparison $\overline{\text{p. 3 and 4}}$ and the succeeding molars. In *Temnocyon* $\overline{\text{p. 3}}$ is a simple tooth with somewhat elongated talon or heel, the posterior edge of the protoconid descending more sharply than the anterior. In *Daphænus*, however, the tooth is less simple, there being developed a minute metaconid and the anterior edge of the protoconid descends more sharply than the posterior; the tooth, moreover, shows greater lateral compression and a more strongly marked cutting structure. The increase in size of $\overline{\text{p. 4}}$ over $\overline{\text{p. 3}}$ is regular and proportionate to the increase between $\overline{\text{p. 3}}$ of *T. altigenis* over *Daphænus*. The main cone does not incline backward and the anterior edge is less sharply inclined. The metaconid is developed to a greater height, with apex less obtuse than in the type of *Temnocyon*. The heel is rather flat and the entire tooth shows greater lateral compression.

The contour of the crown of $\overline{\text{m. 1}}$ in *Daphænus* is more like *T. ferox* than that in the type species, in this latter being very irregular with much compressed centres; the antero-posterior diameter is one-third less, a proportionate diminution. The hypoconid is nearer the middle of the tooth than it is in *Daphænus*: the entoconid is very minute, if developed at all. The anterior position of the tooth closely resembles both species of *Temnocyon* under consideration, but the posterior more nearly that of the larger species. In fact, taking into consideration the proportionate difference in size and the fact that the entoconid, while being very minute, is proportionately more robust in *Daphænus*, the tooth is nearly identical with that of *T. ferox*.

$\overline{\text{M. 2}}$ is equal in size to that of *T. altigenis* and, hence, is proportionately more robust. While the protoconid in *Temnocyon* is developed near the middle of the tooth, it is in *Daphænus* pushed anterior thereto, rising from the extreme anterior edge; its height is equal to that in the type species. The hypoconid is however not so robustly developed in *Daphænus*. This part of the tooth is noticeably elongate and in consequence the separating valley or groove is not so sharp as in *T. altigenis*.

$\overline{\text{M. 3}}$ is elongate and generally flat, the two cones being very minute, the anterior one slightly the larger; the antero-posterior diameter is 4 mm, transverse 6 mm. The tooth overlaps $\overline{\text{m. 2}}$ at the posterior internal side.

The surface for the alveoli of the dentition of the ramus of *Daphænus* is nearly level or flat, but in *Temnocyon* it inclines upward and backward with an easy curve from $\overline{\text{m.1}}$. In the former the curve, which is rather sharp, commences at the posterior of $\overline{\text{m.3}}$. The diameter of the ramus from the posterior end of the dentition to the point where the bone curves upward to the condyle is 88 mm. in *T. ferox* and 53 mm. in *Daphænus.* A horizontal line drawn along the base of the dentition will in *T. ferox* pass below the condyle and in *Daphænus* above it and the coronoid process is less anterior to the condyle than in the former species. (The mandible as a whole approaches nearer to that of the living *C. familiaris* than to that of *Daphænus.*)

The limb bones of *Daphænus* which are available for comparison are the humerus, ulna and femur and these indicate a skeleton of smaller size than the skull would lead us to expect; however this is true also of *Temnocyon* but in a less degree.

The shaft of the humerus is slender and not so erect as in *T. ferox*, but curves backward. Judging from the position of the head of the proximal extremity the articulation with the scapula must have taken place at a greater backward angle than in *Temnocyon*; the deltoid ridge is well developed and there is an epicondylar foramen. The distal trochlea appears to be much lower and more primitive.

The ulna is slender and does not curve backward as in *Temnocyon*; the diameter of the sigmoid cavity is 13 mm. and of the shaft at this point 11 mm. The articulation with the radius is lateral, rather than anterior as in *altigenis* or *ferox.*

The shaft of the femur is slender and is compressed antero-posteriorly throughout its entire length, which is 145 mm.; the head is well rounded and has a diameter of 19 mm.; the neck is thick; the greater trochanter is placed on a level with the head and is well developed; the lesser trochanter is but 12 mm. below the head; a third trochanter is present 33 mm. below the apex of the greater.

Dr. Scott in his table (No. 6, p. 75) shows the descent of *Temnocyon* (as well as *Cynodesmus*) from *Daphænus*, and it is evident from the above comparison that the later John Day genus is more advanced and more modern in its development than its predecessor *Daphænus* of the White River.*

HYPOTEMNODON. Eyerman (No. 2. p. 321).

Talon of inferior sectorial trenchant; internal cingulum greater and more pronounced than in *Temnocyon*; inferior second molar tubercular, *with internal cusps* equalling in size those of the external side.

Hypotemnodon coryphæus.

(*Temnocyon coryphæus* Cope, No. 1, p 906.)

Description and comparison with T. altigenis Cope.—The anterior bones of the jaws supporting the dentition are considerably less elongate. The diameter across the malar bones is equal in both species and hence proportionately more robust in the new genus (being the smaller). The premaxilla extends to a greater distance beyond the nasal, the incisors and canines inclining forward and outward to a greater degree than in *Temnocyon*, in which they are erect. The superior dentition shows marked differences in position and development. In the type of *Temnocyon* the largest incisor and the canine are placed close together in a direct line, whereas in *H. coryphæus* they are separated and the incisor is anterior to the internal edge of the canine, in this respect resembling somewhat the position in *T. ferox*. The canines have a greater base development and equal that of the considerably larger species (*T. ferox*), but only at the base, for the height is nearly three times less than in the larger species, and p. 1-2 are simple teeth varying only in size, those of *T. altigenis* being more elongate in proportion to their width; p. 2, however, in this latter species, is formed nearly in the shape of a right angle, the anterior portion pointing forward and the posterior outward.

In p. 3 there is a minute cusp at the posterior in both species, and, while the antero-posterior diameter in *T. altigenis* is considerably greater than in the new genus, the transverse diameter is less, and, further, while the greatest transverse diame-

*It has been noticed above that *T. ferox* instead of the type, *T. altigenis*, is frequently used for comparison with *Daphænus*; this is due to the fact that the mandible of the type, *T. altigenis*, is incomplete, whereas that of *T. ferox* has preserved the parts which are missing from the mandible of the former species.

ter in the type of *Temnocyon* is at the anterior and the cone rising from this portion of the crown, in the new genus, the greatest diameter is at the centre with the cone rising therefrom.

In *H. coryphæus* the transverse diameter of p. 4 is less than in the type of *Temnocyon* ; the deuterocone, which is of equal development in both, is in the former species separated from the protocone by an elongated neck, which differs very much from the robust development at this point in the latter species; the protocone has rather a more cylindrical shape, inclined backward, than (as in *T. altigenis*) an erect pyramidal one. Above the anterior portion of this tooth in *Hypotemnodon* the malar bone projects over the maxilla, but in *Temnocyon* above the middle of m. 1.

In m. 1 the external edge inclines backward and outward to a greater extent than in the type of *Temnocyon* and in this species the para- and metacones are crossed by a ridge which gives the two cones a laterally compressed appearance; this is absent in *Hypotemnodon*; nor is the groove between the two cones so well defined; the protocone is more flattened and is nearer the middle of the internal edge and the internal cingulum is less well defined than in the type species; m. 2 is so badly worn as not to admit of comparison; the transverse diameter is 12 mm. in *T. altigenis* and 8 mm. in *H. coryphæus*, while the antero-posterior is 7 mm. in the former and 4 mm. in the latter.

P. 3 and 4 and succeeding molars of *Hypotemnodon* and p. 2-3-4 and m. 1 and 2 of *T. altigenis* only are available for comparison. In the several species of *Temnocyon* the width of the lower jaw decreases in proportion to the decrease in length, but in *Hypotemnodon* the decrease is less and not in proportion to the length. P. 3 is slightly larger than in *Hypotemnodon* and is of simple structure. In the latter genus a small metaconid is developed and there is an incipient cusp at the anterior extremity, as well as a posterior marginal lobe. The tooth exhibits a good type of the cutting structure. P. 4 is nearly identical in both species, with the following exceptions: the tooth is more compressed and exhibits a more marked cutting structure than in *Temnocyon* and the talon is more elongate and the metaconid less strongly developed: the greatest transverse diameter is at the centre and in *Temnocyon* at the posterior end. The heights of $\overline{\text{p. 3 and 4}}$ are equal in the former, and in the latter species (*T. altigenis*) the fourth premolar is some 4 mm. higher than the third.

While the preceding premolars are proportionately larger than those of *Hypotemnodon*, in $\overline{\text{m. 1}}$ they are of equal size in both species, and hence this molar shows greater development in the latter or smaller species; the height, however, is less than in the type of *Temnocyon*, and we find, too, that the crown is considerably compressed between the proto- and hypoconids. The anterior end of this tooth overlaps the internal of $\overline{\text{p. 4}}$, but in the type of *Temnocyon* the teeth are separated; the entoconid is more robust in the new genus and is separated from the protoconid by a deep groove. The base of the protoconid is rather weak, with greater upward curve and with more pronounced cingulum as compared with *Hypotemnodon*. $\overline{\text{M. 2}}$ is proportionately larger and more robust, with the protoconid twice the height of that in the new genus; in both species the hypoconid is smaller than the protoconid. In *T. altigenis* these two cones are placed along the median line, but in the new genus are nearer the external edge, this being due to the presence of *internal cusps* which are not developed in *Temnocyon*. A third tubercular molar is present in *Hypotemnodon*, placed internal to the external line of the crown of the preceding molars and measures 5 mm. in antero-posterior diameter and 3 mm. in transverse. In *Temnocyon* there is a distinct alveolus for this molar, but the tooth itself is absent.

From the above description it is obvious that Cope's *T. coryphæus* (No. 1, p. 906) should be removed from the genus *Temnocyon* and a new genus erected, to which has been given the name *Hypotemnodon*. This genus is represented by the cranium and left ramus, which were collected by Dr. J. L. Wortman in the John Day Bad Lands of Oregon.

Authorities Quoted.

1. Cope, E. D. The Vertebrata of the Tertiary Formations of the West, Book 1 (Vol. III of Hayden's Survey of the Territories), 1884.
2. Eyerman, John. The American Geologist, vol. XIV, no. 5. 1894, p. 320.
3. Lartet, H. Bull. Soc. Geol.. vol. VII, 1836.
4. Leidy, Joseph. Extinct Mammalia of Dakota and Nebraska, Jour. Acad. Natl. Sci., VII, 2, 1869.

5. Scott, W. B. Notes on the Osteology and Systematic Position of *Dinictis felina* Leidy, (foot note 2), Proc. Acad. Natl. Sci., 1889.
6 Scott, W. B. The Mammalia of the Deep River Beds, Trans. Am. Phil. Soc., vol. XVII, pp. 55-185.

EARLY PLEISTOCENE DEPOSITS OF NORTHERN ILLINOIS.

By Oscar H. Hershey, Freeport, Ills.

Introduction.

In the spring of 1892, excessive rainfall, with consequent prolonged flooding of the streams of northern Illinois, excavated or re-opened an old ravine on the south bank of Yellow creek, one and a half miles south of the city of Freeport, thereby exposing a very interesting section through clays and silts, underlying and consequently older than the Kansan drift sheet of the region. Since then, the formation of an extensive talus has greatly obscured the section, and, as many years may elapse before it can be again studied, it will be well to place it on record, and the present paper is an attempt to discuss the significance of its phenomena.

The following is the section as exposed several years ago:

Section on Yellow creek near Freeport.

	Thickness.
1. Black surface soil	1 foot.
2. Sandy brown clay, chert, and boulders	1 "
3. Gray "hard pan," with some glacial pebbles	6 feet.
4. Red clay and chert	8 inches.
5. Laminated, variegated clays	1 foot.
6. Carbonaceous, laminated clay	4 inches.
7. Light brown, laminated silts	4 feet.
8. Transition to next	1 foot.
9. Blue, laminated silts, exposed	5 feet.
Total	20 feet.

Loess, Aftonian, and Kansan Deposits.

The black soil at the surface of this section has been formed from the remnant of the loess mantle which overspreads the region, but its unusual thinness is due to its situation on the edge of a bluff, favoring its rapid erosion. Intervening between it and No. 2, there are usually from 5 to 40 feet of clays and silts belonging to the several members of the loess of the Pecatonica basin; but, as above indicated, the loess has been reduced here to a soil layer of one foot, resting directly on the reddish brown clay of No. 2.

This latter is the old interglacial soil of the Aftonian epoch, and presents features characteristic of that stage of the Glacial period. After having thoroughly compared it with the ancient soil developed all over northwestern Illinois, and having traced the direct continuity between the two, it is impossible to doubt its nature and age. It is essentially a till or boulder-clay with a small percentage of sand and a few scattered subangular pebbles and small boulders of foreign derivation and a somewhat larger quantity of angular white chert fragments. This deposit has been oxidized, leached, and darkened in color, and has so peculiar characteristics that it can be distinguished at a glance from all other formations of the region.

No. 3 of the section is the till or boulder-clay, or, as it is frequently called, "hard pan," of the Kansan drift sheet (unmodified, except by a certain amount of oxidation and leaching consequent on its having formed for a long time the subsoil of the Aftonian interglacial soil). It is here a stiff, light yellowish gray clay, presenting on very fresh surfaces a slight appearance of an irregular laminated structure, produced probably by the pressure of the ice, as it is a portion of the ground moraine or subglacial drift; or perhaps this structure may be due to the subsequent action of percolating waters. At this place the deposit contains comparatively few pebbles (among which, however, I have found some beautifully striated); but on tracing it along the bluff to some distance, it is found to abound in glaciated foreign rock fragments, and to be as characteristic a till as any in America. I have dwelt thus long on this least important portion of the section to show that there can be no reasonable doubt of the early age of the lower strata here exposed.

When the ice first invaded the region about Freeport, it found a moderately rolling surface covered with a prevailingly red clay soil abounding in white angular chert. This red stony clay was partially frozen before the ice reached it, and at many places escaped a complete removal, still remaining under the drift sheet as isolated remnants of a once continuous mantle. The 8 inches of red clay and chert (No. 4 of the section) are a portion of this ancient preglacial soil, which has been eroded by the ice from a slight ridge of rocks now buried under glacial deposits, but the existence of which the eroded bank of the creek reveals just east of the ravine. Thence it was pushed forward and deposited in hollows of the surface of a previous lacustrine deposit. It contains no glacial nor foreign pebbles, but its structure indicates a crushing and movement by the ice. This, together with similar deposits in all portions of the district, seems to me to indicate that the Kansan ice-sheet, which deposited the boulder-clay of northwestern Illinois, was the first to reach the vicinity of Freeport, and when it did so found an undisturbed preglacial soil in possession of the surface. (In passing, I may remark that, among all the exposures of pre-Kansan soil examined by me, no instance has been observed of the preservation of any black carbonaceous surface soil; and it is presumed that none existed, but that the red clay as now seen, although evidently chiefly a subsoil, also extended nearly or quite to the surface, indicating undoubtedly a warm climate, since red soils are characteristic of the southern states and of tropical lands and are evidently related to their climatic conditions. The Aftonian soil was red also to a certain extent.)

Before proceeding to a discussion of No. 5, I wish to describe another section, situated in a cutting of the Illinois Central railroad two and a half miles southeast of Freeport. The surface deposit consists of from 3 to 5 feet of light brown loam of Upland Loess, with the usual black soil at the surface. Below this there are about 8 feet of the boulder-clay series, divided into 5 feet of yellow till, overlain by about 3 feet of the reddish brown modified till constituting the Aftonian interglacial soil. Canadian pebbles abound and striated stones are frequently found in the lower portion of the series. The western end of the cutting shows heavy deposits of waterworn gravel, sand, and boulders, of the esker series, resting partly on the rock and partly on the laminated clays which I am about to describe. These occur directly under the boulder-clay, and are not separated from it by any erosion interval or other hiatus; the formation of one followed immediately on the formation of the other. The laminated clays in this type section have an exposed thickness of 15 feet. Their composition is essentially that of the boulder-clay. But there has been a slight sorting of materials by the action of currents in the body of water in which they were deposited, causing the color to vary in different layers from a dark brown, through the various shades of red, to light yellow and gray. Four fine sections of this formation are known to me in the valley of Yellow creek between this locality and Bolton, 8 miles west, besides half a dozen less important exposures. From a study of them all, I learn that it is a deposit laid down in an extra-glacial lake which occupied the valleys of the Pecatonica river and Yellow creek and their tributaries. being due to the obstruction of the lower portion of the former valley by the advance of the Kansan ice-sheet across its mouth.

Lake Pecatonica and its Stratified Clays.

An examination of any map of Illinois will show that the Pecatonica river, unlike any other Illinois stream of equal size, pursues a general east-northeast course from the city of Freeport to its mouth near Rockton. This course is directly contrary to that which was taken by the advancing ice-sheet, and consequently as soon as its border had crossed the Rock river valley and occupied the lower portion of the Pecatonica basin, a ponding of the waters in the still open portion of the valley resulted. As soon as the water level had risen sufficiently to permit its outflow through certain transverse valleys on the watershed south of the basin, this lake Pecatonica maintained a nearly permanent level which I should place somewhere between 60 and 75 feet above the present flood-plain at Freeport. The mud thrown into the lake from the ice-sheet was carried by its currents and everywhere deposited over its bottom, following its inclination "up hill and down hill." Glacial pebbles are sparsely scattered through the deposit. and at the type section an 8-inch boulder of dolerite was found embedded near the base. This small boulder, in falling from the surface of the water, indented the laminated clay on which it fell, and afterward compelled the next layers to curve up over it. Now there is absolutely no way whatever in which this boulder and the scattered pebbles could have reached this locality except by means of floating ice. Remember that the country had not yet been glaciated, as the Kansan ice-sheet was then just advancing toward its farthest limits. These pebbles were brought from the front of the ice-sheet by small bergs that broke off along the water front and were borne over the lake, gradually melting and dropping an occasional pebble or small boulder which sank to the bottom and became incorporated with the laminated clays. There is a total absence of fossils of any kind, which testifies to the arctic severity of the climate during the advance of the ice-sheet.

At the type locality the laminated clays, here situated about 60 feet above the present stream level, are terminated in the end of the cutting by a slight but sharp ridge of Galena limestone, to which they owe their preservation. But intervening between the clay and the rock there is a bed of bright red and yellow fine-grained sand, which seems to be the shore deposit of the ancient lake. These beach sands were derived largely from the neighboring shore land. Among all the different deposits of Quaternary age developed in northern Illinois, the variegated clays under discussion present the finest lamination. The surprising feature of it is its regularity. From top to bottom of the formation, the laminæ vary but little from a thickness of slightly less than a fourth of an inch. What caused the lamination? Apparently the layer of clay belongs to a time of constantly muddy water, which we may attribute to melting ice. The interval between the layers seems to indicate a quiescence of the mud deposition, due apparently to a failure of the ice-sheet to supply the material, which of course means that the ice had ceased to melt to any great amount. If we assume that we have here evidence of periodic changes in the condition of the advancing Kansan ice-sheet, the question still remains as to the cause of these changes and the length of the periods. Evidently climatic change is the only cause capable of inducing periods of melting ice to recur regularly, divided by intervals when little or no ice melted.

Now, if we assume that these periods were similar to the periodic changes of some years' extent in the present climate, as indicated by a study of the behavior of alpine glaciers, we find ourselves obliged to accept an enormous length for the Glacial period. The deposit, at the type locality amounting to a thickness of at least 15 feet, began to form when the advancing ice obstructed the lower valley; and its formation ceased when the ice reached it and pushed back the lake border to a more western position. This assumption would imply, therefore, that about 750 laminæ of clay had been deposited during so many warm periods, each of several years' duration, while the ice-sheet had advanced about twenty-five miles.

A better hypothesis would be to consider the periods to correspond to the annual seasonal changes which must have affected the climate then as well as now. During the long frigid winter the ice remained frozen, and but little glacial rock-flour was supplied to the lake to be scattered over its bottom by the gentle currents which carried it to the most western parts. But when the hot summer sun beat down on the ice, it rapidly melted; the lake became warmer, undermining the glacier; small icebergs broke off and floated out into the lake; and through these means the exact conditions were produced for the formation of our variegated, laminated lake deposit. Under this theory the ice-front advanced about twenty-five miles during a period approximately 750 years in length. I know that I am treading on dangerous ground in attempting to determine the rate of advance in the ancient ice-sheet, lately designated the Kansan, by means of the lamination of an extraglacial lake deposit; but, by placing the facts before the public, every glacialist can decide for himself what the value of the evidence may be.

Many will consider 750 years as too long a time for so short an advance, but it must be remembered that, although in the region of the glacial lake Agassiz the general retreat of the last great ice-sheet of North America has been calculated to have been as much as 750 miles in 1,000 years, all the phenomena of the Kansan drift sheet indicate much less vigor, both in forward movement and in rapidity of melting and so-called retreat. Furthermore, the retreat of a glacial front under warm climatic conditions must have been much more rapid than the advance under conditions just barely frigid enough to cause a general advance. The time was approaching when the climate would become so mild as to drive back the ice border, never again to reach its old limits. As I may attempt to show in some future paper, the rate of retreat, after the ice-front had again passed to the east of Freeport, was apparently about a quarter of a mile in a year, or twenty-five miles in a hundred years. At that later time the ice was under the influence of a warm climate, as immense esker deposits indicate, and its retreat may well have been five or ten times more rapid than its previous advance over the same region. In short, I do not consider the period of 750 years for the twenty-five miles of advance as at all improbable, and, in the absence of evidence to the contrary, shall henceforth assume it to be approximately correct.

An especially notable feature of the laminated clays under discussion is the effect produced by the passage over them of a heavy mass of forwardly moving ice. The upper portion of the deposit rarely remains in an undisturbed position. At the type locality occurs the most magnificent faulting and folding, on a small scale, that I have ever beheld. The effect is as though a very heavy advancing body had, in passing over another semi-plastic body, pushed the latter forward and downward, causing the upper layers to become closely appressed and even overturned, with innumerable very small faults. Some of the fault planes are regularly tilted, only a quarter of an inch apart, and have a downthrow of about a quarter of an inch, being traceable from a few inches to three feet. The disturbance extends to depths between 5 and 10 feet below the surface of the deposit. Doubtless much of the upper portion has been removed and incorporated with the till. In addition to this evidence of forward movement of the ice, a mass of till has been forcibly injected into the side of an esker deposit. Evidence of considerable strength in the advancing ice is found all over this region. The laminated clays, wherever exposed, are much disturbed at their top, although below sometimes showing only a gentle undulation of the strata. At one place, about six miles farther west, the laminated clays appear to have been frozen, and the advancing ice broke them up into irregular masses, which were redeposited, along with sand and similar boulder-like masses of till, in a confused manner, at first sight constituting a very puzzling section. Usually these clays are not in sight, either lying deeply buried under drift, or having been removed during the subsequent glaciation of the country.

These variegated, laminated, unfossiliferous clays of lacustrine origin in the Pecatonica basin, belonging to the Kansan epoch, are of sufficient scientific, if not economical, importance to deserve a name, and I therefore suggest that they be known as the *Lake Pecatonica formation.*

KANSAN BURIED LOESS.

Returning now to our section, we will pass over, for the present, the thin stratum of black clay (No. 6), and will describe the next three beds of silts, which are essentially one formation, differing chiefly in color. The whole deposit is a very fine sand or silt, consisting of mostly well rounded grains of transparent quartz, flint and chert grains of all colors, varieties and shapes, small granular particles of clay and of iron oxide, and minute irregularly shaped particles of carbonaceous matter. In structure the deposit is laminated, but not in the perfect and regular manner of the glacial clays above. At first sight it would be taken as a clay, but on close examination it is readily seen that minute lens-shaped masses of very fine silt alternate with similar masses of slightly coarser silt, varying in size even to quite distinctly visible layers of sand. This exceedingly irregular lamination seems to be nothing more than simple ripple-marks. There was a constant movement of the exceedingly fine sand on the beach and in the neighboring shallow water by small rippling waves.

The section only records 10 feet of this formation, as that was the greatest thickness exposed at any one point. But at the upper end of the ravine the surface of the silt has an elevation of 15 feet above the present flood-plain deposits of Yellow creek, and I have dug five feet below that flood-plain level without reaching the base of the silt. There are, in addition to the ripple-marks just described, faint lines of stratification, yet sufficiently distinct to enable me to determine that the strata are nearly or quite horizontal. Consequently I have seen a thickness of 20 feet of these strata, without having seen either the top or bottom of the formation. Such a deposit as this, especially when we consider its age, must be of exceptional interest to glacialists. I will therefore endeavor to indicate my conclusions in regard to its origin and age; but it must be remembered that, as this is the only exposure of this peculiar formation, so far as I have been able to discover, the data for drawing conclusions are very limited, and future studies may show them to be entirely wrong in many particulars.

First, there is no question that this formation was deposited in water. The structure alone, without considering the other evidence, would make this a certainty. No æolian or glacial hypothesis can account for the stratification and ripple-marks. But the question remains as to whether it was deposited under fluvial or lacustrine conditions. When the Tertiary era came to a close. the valleys of northwestern Illinois were shaped somewhat as now, although the slopes were steeper and outcropping rocks more numerous. The cause of the termination of the peculiar conditions of the Pliocene period, and of the institution of the Pleistocene period, is generally recognized to have been a great epeirogenic uplift of nearly the whole of North America. Northwestern Illinois, of course, participated in this elevatory movement, and the streams, which had long before reached baselevel and widened their valleys to a great extent, now again trenched their river beds down into the solid rock, so that during the early part of the Quaternary era they excavated not inconsiderable valleys in the bottom of the old Tertiary valleys. These new valleys are, in the upper Mississippi basin, mostly buried under an accumulation of glacial and later deposits, and for this reason they cannot be examined. In the Pecatonica basin all the larger valleys have their rock bottoms 100 feet or more below the present stream level. If there are any considerable remnants of preglacial river deposits still remaining in northern Illinois, they must lie on the top and slopes of the rock terraces which careful studies of the valleys and of well sections show to exist below the present bottoms of the valleys. Large quantities of a peculiar river gravel have been plowed up by the ice from some low-lying position in the Pecatonica valley and have been incorporated with the drift over the upland country to the west. No such gravel is known to be exposed *in situ* anywhere in the region, and I am strongly inclined to believe that it really represents some preglacial deposit buried in the valley.

It is assumed that the glacial periods of past times have been largely due to elevation of the land. It seems to be a fact, however, that the climax of the Quaternary stages of glaciation was reached long after the elevatory movement had culminated and the land had returned nearly to its former level. Our region, once greatly elevated to admit the excavation of the deep Quaternary valleys, had again subsided to a comparatively low level in the Kansan epoch, although still higher than at present. But we have no evidence that, previous to the formation of the Kansan drift-sheet, the land had sunk to so low a level as to permit the streams of northwestern Illinois to form a flood-plain, reaching to at least fifteen feet above the present food-plain level. On the contrary, evidence adduced in other regions, as well as here, indicates that the land stood, from the time of the great elevation to the Kansan epoch, continuously higher than now. Consequently, although the silt under discussion presents a few features slightly favoring a fluvial origin, it can not be a river-swamp deposit.

Obstruction of the Pecatonica valley by westwardly moving ice has repeatedly produced a lake in the valley west of the ice-front. We shall now consider the hypothesis that the silt was due to that cause. It bears such a strong resemblance to certain loess deposits that glacialists who have seen it have promptly pronounced it "a buried loess." Its composition is essentially that of a glacial deposit; but there is nowhere in the Pecatonica basin any rock formation that could have supplied the material for its formation. Besides, as this region had not yet been glaciated, the derivation of its evidently glacial material must have been from some region on the east. Since no silt could be carried westward in the valley except when occupied by a lake through the obstruction of the mouth by ice, we thus have evidence that such a lake existed earlier than the lake Pecatonica already described, and that the ice-front then stood, as again later, on some line west of the Rock river.

This entire deposit was originally of a uniform deep blue color, due principally to the variety of iron oxide which it contained. Not only is this color chiefly associated with glacial deposits, but it seems to be characteristic of clays and silts of cold climates. I have mentioned that particles of carbon are disseminated through the deposit. These indicate that the waters came in contact, somewhere in their course, with vegetation. Small broken branches of trees have been found, but are very rare. The nature of the vegetal remains is not such as to indicate the existence, on the neighboring hills, of a luxuriant vegetation like that of a warm temperate climate. On the contrary, cold temperate grasses and small scrubby trees, mostly red cedar, appear to have been the flora of the region in that period. Of the contemporaneous fauna little is known. There are, sparsely scattered through the deposit, small gastropod shells of two species. Unfortunately, owing to a want of knowledge of the importance of these fossils, none were preserved by the writer, and at present the falling of the banks buries them under a talus. It was particularly observed, however, that these shells seemed to be depauperate forms of species that existed in larger forms in the streams of the later Aftonian interglacial epoch. Where most numerous, their number may be roughly estimated at 1,000 per cubic foot, and throughout the deposit they may average several hundred in the same bulk of silt. Portions of the river alluvium of the subsequent Florence subepoch of the Columbia deposits of the same region contain as much as fifty shells per cubic inch. The exceedingly limited number of species, the scarcity of their remains, and the apparently depauperate forms, strongly indicate a cold and almost frigid climate in northwestern Illinois at the time of the deposition of our "buried loess" or blue silt.

Digging into the blue silt in the bottom of the ravine, I encountered a stratum, about eight inches in thickness, which contained a great number of pieces of angular white chert, such as is common in the Galena limestone and its residuary material. This chert was imbedded in the blue silt in a definite stratum, but not in stratified form. As already stated, such white angular chert made up a large part of the preglacial soil of the region, and it undoubtedly was strewn quite plentifully on the surface of the surrounding hills and shores of the lake. I was at first inclined to believe that a landslide had brought it into its present position; but the entire absence of the red clay which must have accompanied such a landslide, and the want of any suitably situated ridge near by, induced me to reject this hypothesis and to adopt the following. In the winters the lake was covered with ice, which, along the stony shore, incorporated much of the chert gravel into its peripheral portion. Upon the breaking up of the ice in the spring, this gravel was carried out into the lake and scattered over its bottom. The absence of glacial pebbles shows that the chert came from the neighboring unglaciated shores, and not from the ice-sheet which on the east obstructed the valley.

The silt formation under discussion, although only seen *in situ* in this one ravine, was, I believe, widely distributed over the valleys of northwestern Illinois and contiguous areas. Well sections, beyond the Pecatonica basin, are occasionally reported as penetrating a blue laminated "clay" at the base of the drift series. Mr. Frank Leverett, on examining this exposure, stated that he had encountered a precisely similar "buried loess" in Rock Island county. I have secured sections of wells, in Stephenson county, that penetrate a thick deposit of blue silty "clay" which lies under the regular drift series, being apparently the lowest superficial deposit (preglacial soil excepted) yet found in this county. I have been present at the drilling of wells in the Pecatonica valley, when the sand-pump brought up a deep blue silty clay, with many broken bits of white chert, but no drift pebbles. Indeed, I am inclined to believe that all the larger valleys are lined to a great extent with this deposit, which probably reaches nearly or quite to the bottom of the early Quaternary troughs. It also probably was originally spread out over the lower upland country, and, although never reaching as high a level, was perhaps equal in amount to the Valley Loess of the Iowan epoch. In the Pecatonica basin it was evidently deposited in an ice-dammed lake; and perhaps some of the other basins, in which it seems to occur, may have had similar lakes. At any rate, it is truly a "buried loess."

The blue, ripple-marked, stratified sandy silt, containing fossils, at the base of the section in the ravine south of Freeport, with its correlative deposits in different parts of northwestern Illinois, is of sufficient importance to be placed on the list of American Pleistocene formations, and I suggest that it be named the *Kansan Buried Loess.*

Kansan Glacial Recession and Re-Advance.

In our Freeport section, we find that the upper part, to a thickness of 4 or 5 feet, of the blue silt has been changed by some process to a light brown color. This brown silt passes into the blue, through the transition stratum No. 8, by interstratification or interlocking of colors. The cause which changed the color operated deeper in the coarse lenses of silt than in the finer, and crept into the interior from cracks and vertical lines of weakness in irregular tooth-like projections, producing an effect which is common in the calcareous shales of the Cincinnati strata on the "mounds" of this region, and probably due to the same cause. On following the brown layers back into the hill, they are found to change into the blue; but still a certain thickness of brown silt remains at the surface.

The silts are horizontal, while the variegated clays rest unconformably on them, sloping toward the center of the valley, and coming successively in contact with lower layers of the silt. This is an erosion unconformity. As the deposition of the overlying clays preceded the first incursion of the ice-sheet in this vicinity, glacial abrasion was not the cause of the erosion, but the removal of the silt was effected under the ordinary agencies of subaërial and stream erosion. Now it is important, in order to determine the length of the erosion interval here indicated, to know approximately what amount of material was removed. Unfortunately, our exposure is so limited that we can do little more than guess at it. Probably the horizontal layers of silt, now exposed, originally extended far out into the valley, perhaps even across it. If this was so, the amount of material removed was large. Again, any deposit such as this, which could have accumulated to a thickness of 20 or more feet in a position not more favorable to sedimentation than any other, and at a hight altogether above the present stream level, must have been extensively developed all along the valleys of the region. Yet it has been almost entirely removed above the present stream and to a considerable depth below it. As the frequent presence of the variegated clays shows, the ice-sheet effected very little abrasion at low levels; and this fact, with the absence from the till, west of the valleys at Freeport, of any considerable amount of material that could have been derived from the blue silt, makes it certain that the removal of this blue silt not only preceded the arrival of the ice-sheet, but also antedated the deposition of the variegated clays. At any rate, the amount of material removed during this erosion interval was considerable; but I do not think that any long time was required for it. The land still stood at a comparatively high altitude, and as soon as the lake had ceased to exist, the streams, then much enlarged under the increased precipitation of the Glacial period, rapidly attacked the silt, and perhaps a few hundred years were sufficient to accomplish the work. The significance of this erosion interval lies in the fact that, after the existence of the first lake due to the presence of the ice-front on the west side of Rock river, it must have been melted back to the east side of that stream so as to open the Pecatonica basin to a free drainage through the Rock river valley. This fluctuation in the border of the ice may have amounted to only ten miles, or it may have been hundreds. I am inclined to believe, as above stated, that the time of erosion was not long, and that the ice had not retreated far.

The brown silt forming the upper part of the deposit is an old interglacial or, rather, inter-lacustrine soil. The change of color has been effected by an atmospheric oxidation of the iron ingredient contained in the blue silt. This latter, on exposure to the air, now rapidly changes to a dull light red, the iron being converted into the red oxide. But at the time of the formation of the old soil it was converted into the brown oxide or limonite, indicating apparently a cold moist climate. It was before stated that this soil runs down over the old erosion slope of the silt, thereby being formed from successively lower layers of it. Within one foot of the surface the lamination has been mostly destroyed. On the surface of the soil there grew a flora consisting mostly of grasses and other herbaceous plants, the remains of which, found in a very thin layer between the soil and the overlying black clay, have the aspect of the vegetation found in northern marshes.

Carbonaceous, laminated clay (No. 6 of the section), having a thickness of about four inches, occurs immediately over the remains of the plants which grew on the old soil, and dips down over the erosion slope of the silt, being thus unconformable to it, but conformable with, and in fact only the lower portion of, the variegated clays. When the re-advance of the ice-front had again established a lake in the Pecatonica basin, the rising waters found a vegetation in possession of the surface, and perhaps a thin black mucky soil at low places in the valleys; but the lake partially destroyed this vegetation and soil, and incorporated them with the first few inches of its own deposits. It may be of interest to note that a precisely similar succession of conditions occurred during the Trenton period on the site of what is now the Elk Horn valley of Ogle county, Illinois.* During the deposition in surrounding areas of the Buff or Pecatonica limestone, the surface of the St. Peter sandstone rose above the sea level as a small island, bearing a soil about as deep, and in the same condition, as the one above described. Subsequently, at the opening of the epoch of the Blue or Trenton (proper) limestone, when the island slowly sunk below the sea, the water found a quantity of peaty matter or perhaps a locally developed black soil, which it broke up and redeposited as a few inches of laminated black shale, succeeded immediately by the usual, but there very fossiliferous, Blue limestone, just as the lake Pecatonica, after having disposed of all the mucky soil that it could reach, continued with its normal deposition of variegated clays. It is not intended to presume that the climatic conditions were similar in these two areas at so widely separated periods, but simply to show that the deposits supposed to represent that Lower Silurian soil have so much resemblance to undoubted buried soils of Pleistocene age as to make the existence of the former well-nigh a certainty.

SUMMARY.

The general course of events during the earlier portion of the Pleistocene period in the Pecatonica basin, according to the study presented in this paper, was as follows:

1. Great epeirogenic uplift, resulting in excavation of deep valleys in the bottom of the Tertiary troughs.

2. Gradual subsidence of the land. Accumulation of the Kansan ice-sheet.

3. Advance of the ice border to the west side of the Rock river, causing obstruction of the Pecatonica valley and the formation of a lake in which was deposited a blue silt or loess (Kansan Buried Loess), the material being derived chiefly from the débris contained in and under the peripheral portion of the ice. Climate apparently almost frigid.

---

*AM. GEOLOGIST, vol. XIV, pp. 169-179, with map, Sept., 1894.

4. Retreat of the ice-front to the east side of Rock river, giving free drainage to the Pecatonica basin, and hence destroying the lake. Extensive subaërial erosion of the blue silt, with the formation of a soil at its surface, while the former lake area was occupied by marshy vegetation. Climate apparently cold temperate, such as would exist as long as the ice lay within 50 or 75 miles distant from this district.

5. Re-advance of the ice-front to the west side of Rock river. Formation of the later lake Pecatonica, on the site of the previous and similar extraglacial lake. Deposition of variegated clays, with iceberg-carried pebbles and boulders, named the Lake Pecatonica formation. Climate evidently arctic.

6. Continued advance of the ice-front, driving the lake in front of it, and finally destroying it altogether by filling the valleys with ice.

7. The front of the continental glacier reaches its farthest limit, 20 miles west of Freeport; remains stationary, in the culmination of this Kansan epoch, sufficiently long to accumulate a boulder belt and faintly defined moraine; then begins to melt away, slowly at first; afterward it dissolves faster under the genial conditions of a milder climate, until within a few hundred years it entirely abandoned northwestern Illinois.

It is desired to call the attention of glacialists to the following points:

1. The Kansan ice-sheet, in occupying the territory that is now northern Illinois, advanced or moved as glaciers do at the present day, not being formed *in situ* as some have supposed.

2. During the general advance, there were fluctuations of the border of the ice, similar to those which produced the successive moraines during the general recession of the ice-sheet in the Wisconsin epoch.

3. The climate was constantly severe during the accumulation and general advance of the Kansan ice-sheet, but varied from cold temperate to arctic in periodic changes, of which the several recorded in this paper were probably only a small portion.

4. Even during the advance, the summer season was attended with more or less melting of ice and of the yearly ac-

cumulation of snow. The forward movement of the ice-sheet, in excess of the amount lost by melting, was just sufficient to enable the front to advance slowly: but when it reached the boundary of the Driftless Area, a slight change in climate overtook it and it began to lose ground, never again to reach quite to its old limits.

ON A SUPPOSED DISCOVERY OF THE ANTENNÆ OF TRILOBITES BY LINNÆUS IN 1759.

By C. E. BEECHER, New Haven, Conn.

Previous to the definite discovery of the appendages of trilobites by Billings[3] in 1870, paleontologic literature contains quite a number of claimants to this honor. Most of them, however, are manifestly erroneous, and the two or three which bear some semblance of validity are too obscure to be of any scientific value. Barrande[2] reviews all the reputed discoveries known to him, but curiously enough overlooks what is probably the earliest reference to this subject. He concludes that—the few scattered observations of parts found which might belong to the trilobites have little value and were accepted as such by naturalists, and also—that these parts of the body have never been really observed up to this time by any paleontologist. This conclusion has been generally accepted, and therefore the subsequent researches of Billings,[3] Woodward[12] and Walcott[11] have been considered as the pioneer discoveries towards an understanding of the ventral structure of trilobites.

In a recent communication to the *Geological Magazine* (March, 1896), Törnquist[9] calls attention to a paper published by Linnæus[7] in 1759, in which a specimen of *Entomolithus paradoxus* Linnæus (= *Parabolina spinulosa* Wahlenberg sp.) is described and figured (*loc. cit.*,[7] pl. I, fig. 1), showing apparently a pair of antennæ in the proper place.

Törnquist believes that this discovery has been lost sight of from the beginning, and reasserts the original claim. He gives the following translation of that portion relating to the antennæ (*loc. cit.*, p. 22). ' " Fig. 1 is one of the clearest specimens I ever saw among so many thousands. Most remarkable in this specimen are the antennæ in the front, which I never saw in any other example, and which clearly prove this fossil to belong to the insects' (= Arthropoda)."

A critical examination of the available data relating to these statements seems desirable in view of its importance, and from the fact that the most recent researches on the structure and affinities of trilobites date from the discovery of the antennæ of *Triarthrus* by Valiant, as published by Matthew[8] in 1893.

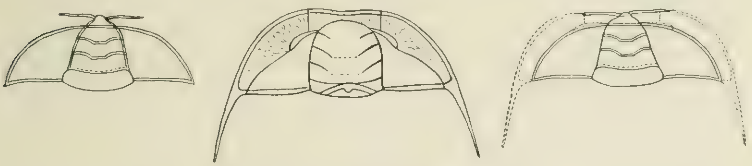
The foregoing observation by Linnæus has not been overlooked, as Törnquist supposes, for nearly a hundred and forty years, but was undoubtedly given all the consideration it merited. Brongniart,[5] in 1822, describes an individual of the same species (*P. spinulosa*) in which there was a suggestion of an antenna produced by an impression of a portion of the head of another specimen. He remarks (*loc. cit.*, p. 33) that "cette circonstance me fait soupçonner que cet échantillon pourrait bien être celui qui a été figuré par LINNE dans les Mémoires de l'Académie de Stockholm. On sait qu 'on y a dessiné des antennes; il est possible que cette empreinte ait été prise pour cette partie par le peintre." And in the introductory portion he says (p. 5), "Enfin ni moi, ni aucun des observateurs qui ont étudié ces animaux n'y ont jamais rien vu qui pût être comparé à des antennes ou à des pattes."

The original figure by Linnæus was also cited by Dalman,[6] in 1828, who says of it (*loc. cit.*, p. 73), "Sed capite exserto et antennis praedito delineatus!" Wahlenberg and Angelin give the same references to the original, and the former in describing his species *Entomostracites spinulosus*, in 1821, included in it the specimen of *Entomolithus paradoxus* of Linnæus with the supposed antennæ.

Any one who will take the trouble to examine Linnæus' figure will concede at once that it is a very crude representation of a trilobite, and is an especially poor illustration of the species, *Parabolina spinulosa*. Just why it was referred to this species cannot now be easily ascertained since it lacks all the really specific characters attributed to this form by Angelin,[1] and later, with greater accuracy, by Brögger.[4] Linnæus' figure gives no suggestion of the nodes on the annulations of the axis, nor of the characteristic long pygidial and pleural spines. The genal spines are also wanting as well as the eyes, the free cheeks, the facial sutures, and the surface markings. Even Wahlenberg[10] and Dalman[6] were in doubt as to the real species of the specimen figured by Linnæus, for Dalman says (*loc. cit.*, p. 73) "Figura haec nimis dubia a Wahlenberg bis citatur, scilicet ad Asaphum mucronatum, et deinde quoque, etsi cum dubio, ad Olenum spinulosum, quem me judice potius spectare videtur." In order to conclude this examination, however, it is best to accept the current identification as correct, and confine our attention to the supposed antennæ.

Brongniart's explanation, that the antennæ in question were impressions of portions of the head of another individual, seems unnecessary when the details of Linnæus' figure are correlated with an accurate drawing. For this purpose the cephalic portion of the original figure is here reproduced, figure 1, together with an outline of the cephalon of *Parabolina spinulosa*, figure 2, taken from Angelin and Brögger.

1 2 3



Parabolina spinulosa Wahlenberg.

FIGURE 1.—Reproduction of the cephalic portion of the specimen figured by Linnæus, with the supposed antennæ.
FIGURE 2.—Complete cephalon, after Angelin and Brögger.
FIGURE 3.—Restoration of figure 1.

This species is a normal form, having a neck segment and four annulations in the glabella, figure 2. Therefore, the projecting portion of the glabella, in figure 1, is the anterior lobe in front of the eyes, and the margin of the head as represented corresponds partly to the eye lines and to the facial suture. It necessarily follows that the cephalon of the specimen figured by Linnæus is without the free cheeks, and with this interpretation of the figure, *the supposed antennæ can only be homologized with the thickened border between the points where the facial suture cuts the anterior margin.* For the sake of more fully showing its relations with the completed cephalon, figure 3 is given in which the missing parts are represented by dotted lines. The comparatively small size of the cephalon in Linnæus' figure is in itself suggestive that the free cheeks are wanting, as is so often the case among the *Olenidæ*.

REFERENCES.

1. Angelin. N. P., 1854.—Palæontologia Scandinavica. P. 1. Crustacea formationis transitionis.
2. Barrande, J., 1852, 1872.—Système Silurien du centre de la Bohême. Part 1, 1852. Supplement, 1872.
3. Billings, E., 1870.—Note on some specimens of Lower Silurian trilobites. Quar. Jour. Geol. Soc. London, vol. 26, pp. 479-486.
4. Brögger, W. C., 1882. Die silurischen Etagen 2 und 3 im Kristianiagebiet und auf Eker.
5. Brongniart, A., 1822.—Histoire Naturelle des Crustacés fossiles. Trilobites.
6. Dalman, J. W., 1828.—Ueber die Palæaden oder die sogenannten Trilobiten.
7. Linnæus, C., 1759.—Petrificatet Entomolithus paradoxus, sådant, som det finnes uti Hans Excellence Riks-Rådets Högvälborne Herr Grefve C. G. Tessins Samling. Kongl. Vetenskaps Academiens Handlingar, vol. xx, pp. 19-24, pl. 1.
8. Matthew, W. D., 1893.—On antennæ and other appendages of Triarthrus beckii. American Journal of Science, 3 ser., vol. XLVI. pp. 121-125, August.
9. Törnquist, S. L., 1896.—On the appendages of Trilobites. Geological Magazine, London, n. s., dec. IV, vol. III, p. 142, March.
10. Wahlenberg, G., 1821.—Petrifacta telluris Suecana examinata. Nova Acta Reg. Soc. Sci. Upsala, vol. 8.
11. Walcott, C. D., 1875.—Preliminary notice of the discovery of the natatory and branchial appendages of trilobites. 28th Rep. N. Y. Nat. Mus. Nat. Hist., p. 89.
12. Woodward, H., 1870.—Note on the palpus and other appendages of Asaphus from the Trenton limestone in the British Museum. Quar. Jour. Geol. Soc. London, vol. 26. pp. 486-488.

THE DEPOSITION OF GOLD IN SOUTH AFRICA.*

By S. CZYSZKOWSKI. Translated by H. V. WINCHELL.

Theories of the origin of the gold deposits in the unique auriferous region of the Transvaal.

Discussions on the origin of the Transvaal deposits are the order of the day. As in all countries of celebrated mines, like that of Mokta, Bilbao and the island of Elba, sage theories are advanced to explain the genesis of the valuable deposits.

Among these theories the mine operators and the speculators generally choose the one which is most favorable for their schemes and for the future of their mines, and willingly accept their dreams as reality.

*Published by Baudry et Cie. Paris, 8vo, pp. 34, 1896.

It is thus that the theory of a lacustrine basin in the Witwatersrand has been readily abandoned and replaced to advantage by that of an auriferous marine formation whose strata are supposed to extend entirely across southern Africa.

There is seen to-day in Africa the same condition that existed at Bilbao in Spain when the English discovered that celebrated deposit.

Assumed to be an immense bed, 100 meters thick, of pure iron ore, it was supposed to extend throughout the country like the Cretaceous terrane which contained it. It was thought to be unlimited and inexhaustible and he was not highly esteemed who thought otherwise. "It is beyond doubt," concluded one engineer, "that these ores have been deposited by warm springs during the Cretaceous period."

It was the favorite theory, the theory of the day, and was most favorable for future developments; but unfortunately it was false. Our study of this region for the Compagnie de Mokta-el-Hadid in 1877, after the examination of other similar but less important deposits of the Mediterranean basin, instilled in us the conviction that the iron ore deposit of Bilbao was of later date than the Cretaceous formation in which it lay, and that it was probably of Miocene age.

We published in 1879 an article demonstrating the superficial and independent origin of this fine ore deposit. It could be inferred from that article that the deposit was limited and that although important, its exhaustion could be predicted. To-day it is almost worked out.

We published the correct facts regarding the age, origin and characteristics of the island of Elba and of various other points in the Mediterranean basin.

Many engineers and geologists have recognized the real existence of the great Tertiary supply of iron of which Bilbao, Tafna, Elba, Cerro de Hierro (Pedroso) etc., are examples. It is by studying all the phenomena and the entire region in which they occur that we have the best opportunity for comprehending it. It is not wise to take too close a view of ore deposits. An observer stationed at the foot of the Eiffel tower could not give a good account of its form and proportions. Placed at a distance, however, he might obtain a very fair idea of it.

It is, to our notion, by looking at the auriferous region of South Africa in its entirety that we are enabled to form true and rational ideas of the origin, the nature and the probable age of its deposits.

A short time since descriptions and reliable geological studies of this country were rare. To-day there exists a geological society of South Africa which attacks with zeal the interesting problems connected with the gold deposits.

The French engineers in the Transvaal send back interesting documents. The *Annales de Mines* has just given us an important and substantial memoir by M. de Launay, whose conclusions, however, on the origin of the auriferous deposits we find it somewhat difficult to accept. The *Genie Civil* and other reviews publish in their turn interesting studies on the auriferous district of South Africa.

M. Jules Garnier has just presented (March 6) to the "Société des ingenieurs civils" a very interesting paper on the genesis of the gold deposits of the Transvaal.

It appears to us that the moment is opportune for us to add our stone to the edifice and to contribute to the study of the phenomena of the deposition of gold in the southern continent. The facts known already seem adequate for a sketch of the true theory, which shall take account of all the varieties of deposits and all the facts observed. We believe it rational, and like all the other authors of theories, we entertain the hope of seeing it confirmed by facts, by development and by later studies.

The question to be settled is, like that of the Bilbao iron ore, whether the gold is contemporaneous with the beds which contain it.

M. de Launay answers affirmatively and concludes " there has been chemical precipitation of gold and of pyrite during the deposition of the sediments." This is equivalent to saying that the gold was deposited at the bottom of the sea, contemporaneously with the conglomerates. And since the auriferous reefs exist through a thickness of many thousand meters of the formation we must grant, as M. de Launay adds, "the constant presence or the very frequent return in the concentrated waters of the sea of sulphides of iron and of gold in solution."

This theory seems to us as questionable as that which has for a long time passed current as an explanation of the formation of beds containing coal, and which consists in supposing regular rising and falling movements of the earth's crust in order to account for the formation of alternating beds of coal, of schist and of sandstone.

M. Jules Garnier also supposes that the precipitation of the gold was contemporaneous with the conglomerate but thinks that the beds were formed in an inclined position like marine deltas and not horizontally.

We do not see any necessity for creating a new theory to explain the Transvaal deposits. Simple circulation of mineral waters in the earth's crust, similar to that which has taken place in all known metalliferous districts, will explain all the various deposits of South Africa. One single but very important method of gold deposition has, in our opinion, been able to form them all, and that is what we shall attempt to demonstrate. Let us mention in the first place that we find the gold associated with silica and pyrite in all the auriferous regions of Africa. Everywhere the ore has the condition of quartz and auriferous pyrites.

It may be said that this is not a proof of one single origin for the gold; but if it is not a proof it is at least an argument. If there had been successive supplies of gold during one or several geological periods it would indeed be extraordinary to find the phenomenon reproduced with such uniformity and to have seen such constancy in the composition of the mineral springs which brought it out and deposited it.

This then is our first argument in favor of one single supply subsequent to the enclosing terranes: uniformity of composition of the ore.

Origin of mineral waters. Circulation of waters, both surface and deep-seated. Thalwegs and metalliferous strata (niveaux).

In order to be thoroughly understood it is necessary to say a few words regarding the mineral springs to which we owe the deposition of metalliferous beds, to speak of their circulation in the pervious strata of the earth and of the influence of the position and characteristics of the beds on the form and nature of the deposits.

And first, what is the origin of these mineral waters?

The frequent association of metalliferous deposits and eruptive rocks, the presence in the latter of metals in the condition of minute grains or inclusions and the observation of volcanic phenomena have served as a basis for the theory of fumeroles, which although ingenious is none the less debatable. The quantity of metals found in eruptive rocks is so small that it appears absolutely inadequate to account for metalliferous deposits.

Would this separation of metals that appears so extraordinary for entire and enormous massifs of surface rocks take place at great depths? In that case what would become of the fumeroles? The metalliferous deposits would need to be formed before the consolidation of the eruptive rocks. But we find the contrary to be true. The real advent of the metals is always of later date and affects relatively limited surfaces of the rocks. The phenomena of to-day seem to us incapable of explaining the origin of extensive metalliferous regions.

M. Parran in an unpublished work* expresses himself as follows:

"It should be remarked, however, that metalliferous inclusions disseminated through the rocks do not explain the existence of the associated massive and sometimes colossal deposits of compounds of sulphur and iron or copper (Huelva, Tuscany, Chessy, lake Superior [?] etc.) It is necessary to assume either the mechanical introduction of copper matte along with the associated lava or solfataric action which always accompanies eruptive phenomena, or perhaps the two causes together."

We believe that mineral waters may be perfectly independent of eruptive rocks in the strict sense of the term. Metalliferous solutions (emanations) are derived from the molten bath which supports the lava or magma whence all eruptive rocks arise. When vapors carrying metals have reached the solid crust of the earth and find themselves, at a certain point in their ascending course, in the presence of water, the reactions caused by surface waters may produce conditions of which we know absolutely nothing.

*Evolution métamorphique des roches basiques et leur contribution à la formation des dépôts filoniens et sédimentaires. Oct. 15, 1888.

After a folding of the crust and the emission of rocks, the entire zone of disturbance is usually affected and invaded by these mineral waters. Whatever be their origin, it is perfectly well known and demonstrated that ore deposits are produced by mineral waters. These mineral waters have circulated in the earth's crust either ascending under pressure or as surface waters.

The circulation of surface waters is perfectly demonstrated and easily understood. The water of rains or that produced by melting snows percolates downward into the rocks either by means of fractures and fissures or through porous strata such as sands, sandstones or conglomerates. Sheets of subterranean water are produced. When an impervious stratum retains and deflects the waters there is formed a water level. If this water level is held between two impervious beds we have a flowing spring or sheet of water. Thus at Paris, which is situated in the center of concentric strata elevated at their outer edges, a well sunk to a depth of 600 meters encountered a flowing stream of water which has become classic. The sinking of the well at Grenelle was undertaken in 1834 for a scientific experiment. Five years later, in 1839, the depth of 480 meters had been reached without finding water and the advisability of continuation to greater depths was debated. Arago advised further boring to the depth of 600 meters and the famous water was found at 548 meters. The flow was estimated at nearly 4 million liters of clear water per 24 hours, with a temperature of 28 degrees. The well at Passy is 580 meters deep. That at the Say refinery is 600 meters and that at La Chapelle 718 meters.

All these springs were found in the green sands of the Cretaceous and in some places formed columns of water spouting up to a hight of 40 meters above the level of the Seine. This bed of porous green sand outcrops more than 100 kilometers from Paris, at an altitude of at least 100 meters.

In various countries drill holes have brought up fish and particles of swamp plants; and fresh water shells, which could have no other origin than in valleys, lakes or ponds several hundreds of meters away, have been brought up from depths of more than 50 or 100 meters. All these facts prove the subterranean circulation of surface waters. We may recall the fact finally that whole rivers are seen to disappear in limestone areas and to issue again at the distance of several kilometers.

If we suppose now that the surface waters are replaced by mineral waters rising from the depths of the earth we may easily understand the existence of layers and levels of mineral waters. We see that having followed subterranean or superficial thalwegs they have produced the deposits that are found to-day. Faults have played the role of artesian wells; but it is also true that mineral waters under great pressure could circulate in all the cavities of the terrestrial crust. There is then no difficulty in admitting the circulation of mineral waters, either ascending or descending.

These waters, arising from unknown depths and circulating in the joints or fractures, or at the contact of eruptive rocks, have next encountered terranes whose strata were either highly inclined, approaching a vertical position, or gently inclined and nearly horizontal. In penetrating the joints of the former they have formed bed-veins; and following the porous beds of the latter they have formed "niveaux" and metalliferous thalwegs.

All forms of deposits may be explained by this circulation of mineral waters. The deposits at Laurium owe their origin to mineral waters which followed the contacts of schists and limestone beds, alternating in nearly horizontal layers. All through the Mediterranean basin are found beds of iron ore, which have taken the place of limestone, enclosed in an impervious rock, such as schist or quartzyte; and sometimes even yet the course followed by the mineral water may be traced.

Examples of metalliferous "niveaux" are not rare. In France may be cited arkose, which surrounds the central plateau and which contains galena and blende. The beds of galena and blende of Figeac (Lôt) deposited along the bedding planes of Jurassic limestone which has been but little disturbed are a striking example of a metalliferous "niveau." On the Balearic islands, at Carthaginia in Spain, remarkable instances occur.

In steeply inclined terranes bed-veins or interstratified masses are produced. Of this nature are the deposits of Rio Tinto, Tharsis, etc., in Spain.

It is not necessary to dwell longer on this subject. Our aim was to show the possible formation of metalliferous thalwegs and "niveaux." In 1876 we pointed out the existence of metalliferous thalwegs,* and we have had occasion in our works on iron ores to cite some remarkable ferriferous thalwegs.

We will quote finally the opinion of the wise geologist and practitioner, Mr. A. Parran, who expresses himself as follows: "Another class of stratified deposits owes its origin to 'niveaux' of mineral water which has spread through a porous stratum comprised between two impervious beds, and has mineralized this stratum like an ordinary vein." On the subject of the Triassic arkose, Mr. Parran speaks as follows in the work we have just cited: "Some geologists have thought that the metallic constituents of this arkose were contemporary with the sediments. This is extremely unlikely. This gravelly deposit is usually quite coarse and seldom has a thickness of more than 10 meters. It was probably deposited in a short space of time and in agitated waters. Under such conditions it would be difficult to account for local and highly crystalline mineralization with copper pyrites, with galenite, barite and fine needles of carbonate of lead."

General geological sketch of South Africa. Age of the gold deposition.

What has taken place in South Africa? To what geological epoch shall we attribute the deposition of gold? What was the position of the strata when the mineral waters came? What kind of deposits have been produced?

Southern Africa forms part of a very vast ancient continent which emerged at the end of the Carboniferous period and comprised the massifs of Brazil, Madagascar, the Indies and Australia, and which was broken up at a later period by great continental depressions.

Four geological formations are recognized there: The "primitive terrane" composed of gneiss, mica schists and rocks similar to those of Europe surrounds the granitic massifs.

The "formation of Swaziland" distinctly developed in the "de Kaap" district consists of slaty or talcose schists, of sand-

*Minerais de fer en Algerie et considerations générales sur les gisements métalliferes, 1876. Bulletin de la Société scientifique et littéraire d'Alais.

stones and conglomerates. The strata of this formation, among which may be seen primary rocks like the pre-Cambrian, Cambrian and Silurian, are generally steeply inclined.

Eruptive rocks are found there in dykes, cutting the sedimentary rocks perpendicular to their stratification or in bedded dykes, generally striking east and west and related in either case to the metalliferous deposits.

The "Cape formation" and hence that of the Witwatersrand, contains at its base ferruginous schists which are a promising horizon for further investigations. Above it comes the formation containing the auriferous quartzytes and conglomerates. This formation has generally but a slight dip taken as a whole; but on the borders of the folds formed by the strata they are seen to have a steep inclination. In the "de Kaap" district, according to Mr. Van Gember, they appear to be but little disturbed at their contact with the granite, which tends to prove that the granite was there at the time of their deposition. From fossils found at the Cape these strata are known to belong to the lower Devonian. Composed of regular strata of sandstone and conglomerate which indicate a shore line, and resting on the sharply folded strata of the Swazi formation, we are led to the supposition that here, as in Europe, the Devonian is deposited at the foot of a Caledonian range.

The Carboniferous formation is represented by quartzytes and thick strata of dolomyte which rest unconformably on the Cape formation. According to fossils found at one locality by Mr. Draper these dolomytes belong to the lower Carboniferous. This limestone formation extends over vast areas and maintains its uniformity of aspect and horizontal position. It has been affected by the intrusion of eruptive rocks and the advent of gold and other metals.

Finally all these formations have been covered unconformably by the thick and regular strata known under the name of "Karoo." The sandstone formation of the Karoo comprises sandstones and variegated schists which contain important deposits of combustible materials worked at a large number of localities. Extensive erosion has removed this formation over large areas; but remnants everywhere remain which testify to its former distribution over all of South Africa. From the fossils found these strata are recognized as of Permian and

Triassic age. They do not appear to have been folded, but eruptive rocks and a sort of breccia or subterranean moraine (moraine interne) which contains the diamonds of the Cape have penetrated it at several points.

The gold advent of South Africa affected all formations earlier than the Karoo. It is thus later than the Carboniferous limestone and certain diabases. It appears to have belonged to the great Hercynian [from Carboniferous to Permian] age of the deposition of metals, which also gave rise to the rich veins of Australia. That all the strata covered by the Karoo have to-day practically the same general appearance as at the advent of the gold is indicated by the fact that the Karoo has remained horizontal and has not been folded. We believe that the gold was deposited at a period when the strata of the Cape formation were in an undulating position approximately horizontal, while that of Swaziland was on the contrary almost vertical.

From the above considerations it follows that thalwegs and metalliferous "niveaux" would have been produced in the first formation and bed-veins or intercalated masses like those of Rio Tinto in Spain, in the second. And this is what we find in the districts of the Witwatersrand, of "de Kaap" and Lydenburg. It should be stated, however, that after the formation of the auriferous beds their horizontal position was disturbed at some points as a consequence of fractures and orogenic movements as well as by the advent of dykes of green rock which have altered the position of the gold-bearing formation.

Deposits of Witwatersrand. The terrane enclosing the reefs and origin of the latter.

Let us examine the Witwatersrand deposits. Taking a hasty glance over this entire gold region we see several meters north from Johannesburg granite and gneiss forming an east and west ridge between this village and Pretoria. About 20 kilometers toward the south the granite reappears in the Orange Free State. It is between these two granite ridges that we find the gold bearing formation composed of strata of sandstone, quartzyte, schist and conglomerate comparable to the Cape formation and believed to be of Devonian age. The dolomyte formation, which is assigned to the Lower Carboniferous, lies unconformably above the Devonian rocks and at some points is overlain by patches of the Karoo containing beds of coal. The central part of the Rand, which has been the scene of the most extensive exploitations for gold, has a regular structure. The strata strike east-west and dip south about 75°.

Toward the west on the Randfontein side and toward the southwest at Buffelsdorn in the Kleksdorp district as well as in the eastern portion near Modderfontein and toward the south in the district of Heidelberg, at Nigel, there is less uniformity but the gold bearing strata are known to be rich and are exploited. The strike of the strata and of the reefs becomes northeast-southwest, and they have no longer the steep dip that they possess in the northern part of the Rand.

Within the area which includes Kleksdorp, Randfontein, Johannesburg, Modderfontein and Heidelberg has been assumed the existence of a basin of lacustrine terranes in which the beds of auriferous conglomerate were deposited. It is now recognized that this idea was erroneous, and the more reasonable idea of a marine formation has been adopted. M. de Launay presents the theory of a northeast-southwest synclinal. Mr. Jules Garnier holds to the idea of inclined deposits still possessing approximately their original position.*

Whatever be the true theory of these basins or synclinals the grand and rich central region of the principal exploitations for gold shows that the rock strata and reefs which at the surface dip 75° to the south are not inclined more than 30° at considerable depths. Must we admit with Mr. de Launay that these moderately inclined strata have an indefinite extension? We do not see why the horizontal portion of the bottom of the trough and an upward slope toward the south may not soon be discovered; and we believe that such will be the case. We would not be surprized if the bottom of this trough were already reached at certain points in a mine named for a bright future the "Village main reef," situated on the extension of the reefs exploited in the "City and Suburban," the "Jubilee," the "Salisbury" and the "Vemmer."

An examination of the sections of these mines and particularly those of the Jubilee and Salisbury seems to indicate that

*Mr. Jules Garnier's article will appear in the *Mémoires de la Société des Ingenieurs Civils.*

the bottom of the fold will soon be reached. The section of the Ferreira gives the same impression.

We may then inquire whether the considerable depths of which we have heard so much and to which the reefs are to descend are really to be attained. This question is very important, for in case of an upward turn in the formation at a workable depth, the entire wealth of the Rand may be extracted.

Taken as a whole the region is gently undulating and the area of high dip of the richest portion of the Rand which extends over about fifteen kilometers is an exception. It may be explained by the later pressure undergone by the terrane by compression against the granite range situated north of Johannesburg. In general the strata are but slightly folded at Randfontein, at Kleksdorp, at Modderfontein and at Heidelberg.

The zone of Johannesburg alone is steeply inclined and its reefs were at first taken for true veins. It was a surprise, according to Mr. de Launay, when with increasing depths the reefs were seen to have a lower and lower dip and to conform perfectly with the position of the enclosing strata. We will add that it will be a still greater surprise when some day, perhaps very soon, the reefs are seen to rise toward the south in those mines where this change will occur at moderate depths. In short the structure of the Rand strata does not seem to be as yet well determined. All that we can say is that the Rand has been gently folded and that in the portions inclined more than the average such as the central regions of Johannesburg, the east-west trend characteristic of the hercynian chain of Europe is found plainly marked, as well in the gold bearing strata as in the great diabase dyke of Klipriversburg.

In this formation of schists, sandstones, quartzytes and conglomerates of the Witwatersrand there are found a considerable number of strata carrying more or less gold. These are the "reefs." The principal reefs so far recognized are as follows in ascending order:

Preez's reef, or the Rietfontein group, exploited at Rietfontein.

The main reef group, which includes the South reef, Main reef leader, Main reef and North reef.

Bird reef, Kimberley reef. Elsburg reef and Black reef.

The South reef and the Main reef leader are the richest, the most continuous and the most largely developed. Their thickness is not great, varying from a few centimeters to one meter. Their gold content varies from 10 to 45 grammes per ton of ore crushed.

The Main reef, which is larger (one to eight meters) is of lower grade (10 to 15 grammes.) It is now being exploited.

It does not fall within the province of this paper to follow the reefs across the Rand and to examine their variations. This task has been undertaken by de Launay, and the reader is referred to his article in the *Annales des Mines* and to his work now being published by Baudry.

In short the ore appears to be a conglomerate or sandstone impregnated with auriferous pyrite and silicified. It has sometimes undergone metamorphism as at Ferrieira, Buffelsdorn and elsewhere. The gold is never found in the quartz pebbles; but only in the cement which holds them. The principal ore is conglomerate, whose pebbles vary in size from a few millimeters to ten centimeters.

Mineral waters have followed the porous strata,—the sands, sandstones and conglomerates of this Devonian formation,—and have produced the reefs which, as we have said, contain the auriferous pyrite.

The origin of the Black reef is very interesting. In its vicinity there has been an intrusion of diabase, which entered between the quartzyte and limestone, following a general east-west course to Klipriversberg. Belts of quartzyte sometimes occur at its contact with the dolomyte.

The mineral waters, following the line of contact. have rounded the pyrite as it was formed and have produced stratified deposits containing fragments of diabase. The flow of thermal water must have been sufficiently strong to carry along fragments and pebbles of the disintegrated conglomerate and to erode thalwegs or water courses on the surface of the diabase whose intrusion must have immediately preceded the advent of the mineral waters. This diabase is of course of an earlier period than that in the dykes which have disturbed the formation.

Deposits of the "de Kaap" district. Structure of the terrane enclosing these deposits.

In the "de Kaap" district, according to a report by Mr. Van Gember, reviewed by Mr. F. Schiff in the "*Genie civil*," we find first granite, then the Swaziland formation of Mr. Schenk in steeply inclined strata, and the Cape formation generally but gently inclined. The general direction of the Swazi beds is east-west. All the formations are cut by eruptives. Northeast dykes occur in the granite. Others with an east-west trend occur interbedded with the strata and associated with metalliferous deposits, as in the Rio Tinto region of Spain. The granites are cut by auriferous quartz veins which are generally supposed to be too poor for exploitation.

In the Swazi formation the gold-bearing deposits are between the strata, following the planes of stratification or at their contact with the dioryte. There are also veins which cut the strata. The former are the most productive, as in the Sheba for example. Mr. Van Gember rightly believes all these deposits to be veins. The gold is found associated with the pyrite, and also free. The gold content of the pyrite is higher than in the Witwatersrand.

In the Cape formation of the "de Kaap" region there are found beds of auriferous conglomerate which attain a thickness as great as 10 meters; but their gold content is small and irregularly disseminated. The study of these auriferous horizons deserves more particular attention.

District of Lydenburg.—Mashonaland.—Matabeleland.

In the district of Lydenburg the gold deposits occur in the dolomyte which is but little inclined in the regions where it has been invaded by eruptive rocks.

Two auriferous horizons are known and a great number of claims have been taken on them. Four mines are already developed. The deposition of the auriferous quartz has occurred in different strata and small veins of great importance are also often found. The fact that we wish to emphasize here is that the beds are horizontal, and auriferous horizons (niveaux) have been formed.

In Mashonaland and Matabeleland many explorations are actually in progress in the east-west strata supposed to be of the same nature as these of the "de Kaap" district.

Origin and mode of formation of the reefs. Answers to some objections.

The origin and the mode of formation of the gold deposits by the circulation of mineral waters in the porous strata seems to explain all the facts observed. Mr. de Launay objects to what he calls this very seductive theory of auriferous and pyritiferous impregnation of the conglomerate on the ground that it does not satisfactorily account for beds of pebbles of similar size and identically the same structure even over an extent of several meters, of which some are gold-bearing and others barren; and thinks it is absolutely incompatible with the constant presence of rolled pyrites.

This objection is answered by assuming variations in the composition of the mineralizing waters. Coming from the deep regions of the earth's crust they followed, as already described, the porous strata. Let us suppose a stratum of conglomerate traversed by mineral waters of variable composition. Primarily siliceous, they subsequently brought pure pyrite and then gold with the pyrite. Such was the origin of a reef. The siliceous waters would have commenced the work of cementing the quartz pebbles, and would have formed around certain centers in the middle of the bed more or less irregular areas of agglomerated conglomerate, which would become impervious as soon as the cavities were filled with silica.

If it be supposed that at a given period the mineral waters then brought up sulphide of iron, it would form around these sterile areas in the shape of specks in the strata of those zones which contain iron pyrites. The latter would themselves be surrounded by other zones of auriferous pyrites when the epoch of gold deposition began. The cavities once filled, the reef is formed. Thus the juxtaposition of rich and barren zones of auriferous pyrite is easily understood. It is also evident, up to a certain point, that the average gold content of the stratum thus formed would be comparatively constant in a homogeneous area.

The pyritiferous zones parallel or oblique with the stratification, the influence of non-porous schists on the walls, on the richness and continuity of the reef, the influence of large pebbles, etc., are all easily explained. Some entire strata have been cemented by silica alone, others by pure iron pyrites, and hence there are sterile beds alongside of rich ones.

Now as to the question of the rolled pyrites. Its presence seems to us more difficult of explanation on the marine hypothesis than on the supposition that it was deposited subsequent to the conglomerate. In short it seems as though the pebbles of pyrite would have been inevitably crushed and pulverized at the bottom of an agitated ocean and in the midst of quartz pebbles. In a bed of conglomerate already formed, however, where the circulation was gentle, the pyrite as it was formed would be dragged and carried into the sinuous courses which the mineral waters followed between the quartz pebbles or the silicified areas already mentioned. The formation of this rolled pyrite would depend upon the rapidity with which the water flowed, the dip of the strata, and the existence of larger or smaller cavities in the conglomerate and around the pebbles.

Orogenic and metalliferous phenomena of South Africa. Analogy with the South of Spain.

It seems to be established to-day that at epochs of orogenic disturbance internal phenomena are produced in the following order:

1. Folding, elevation, subsidence, fracturing.
2. Great subsidences.
3. Wide-spread intrusion of eruptive rocks.
4. Strong flows of heated mineral and metalliferous waters often preceded, as we believe, by a sort of subterranean moraine of hot mud which sometimes contains ores, and sometimes diamonds as at the Cape. Such would be the complete series of orogenic phenomena of which the formation of ore deposits would be the final term.

Now to sum up the phenomena of South Africa: In the first place east-west folds were formed which affected the lower Carboniferous; then occurred an important intrusion of eruptive rocks, and finally came the advent of metalliferous mineralizing agencies. Some dislocations, faults and dykes must have preceded the deposition of the Karoo.

From this standpoint the gold deposits are of hercynian age as in Australia where the veins cut the Archean, Cambrian, Silurian and Devonian, all of which are much folded; but they always stop at the coal terrane which covers them unconformably.

We will not close this paper without calling attention to the analogies observed between the region of Huelva in Spain and that which has just been discussed.

In the region of Huelva, after the deposition of the Culm, an east-west fold was started, bringing up the marine sediments of that period while the coal deposits were formed in the wrinkles of the central Spanish plateau. Eruptions of porphyry or melaphyr occurred, as in the Esterel in France, and these rocks lodged between the disturbed, east-west strata.

Important metalliferous accessions succeeded these eruptions, affecting an immense area and producing the very remarkable deposits of Rio-Tinto, Tharsis etc., in the region of Huelva, and those of central Spain: Linares, Almaden, Ciudad real, Castuera, etc.

The metalliferous accessions appear to have pursued the following order: iron, sulphide of iron, cuprous iron pyrites, sulphide of copper, lead, silver, zinc, antimony, mercury, gold.

There are regions characterized by ores of copper, others by ores of lead, mercury, or antimony. The copper pyrite deposits have an east-west strike like the enclosing rocks, and are sometimes situated at their contact with basic eruptives.

The great deposition of sulphides of iron and copper followed immediately after the eruption of these rocks. The deposits are formed in wrinkles or zones dislocated and altered by the advent of intrusive masses.

The very abundant mineral waters which have introduced and deposited the sulphides have also been efficient agents in the alteration of the enclosing strata. The porphyries themselves have been greatly altered and decomposed.

Thus, in short: east-west folds, east-west intrusions, east-west metalliferous deposits, Carboniferous rocks affected by the ore-forming agencies, these are the analogies with South Africa.

The ore deposition seems to have been of substantially the same age (hercynian) in both countries. That of South Africa, which is perhaps Carboniferous, may have preceded that of Spain, which is Permian. But while in Spain the iron pyrites was accompanied by much copper and little gold, in Africa it was accompanied by much gold and little copper.

Conclusions.

In closing it seems well to emphasize the following conclusions:

I. The gold is not contemporaneous with the strata which contain it. The container should not be confounded with the thing contained. Each has its geological history and its own mode of formation.

II. Mineral springs ascending from the depths of the earth have circulated in its fractures and through its porous strata and have carried thither the silica, gold, pyrite, etc.

III. All the strata in South Africa which were formerly permeable, such as sandstones, sands, conglomerates, and fissured limestones, are likely to contain gold (up to the Carboniferous).

IV. Portions rich in auriferous pyrites must be looked for in these strata at the contact of impermeable rocks with eruptives.

V. Well defined gold-bearing horizons are found in the zones of terranes which contain nearly horizontal and pervious strata which belong to the Cape formation or to that of the dolomitic limestone of the Carboniferous. Such are the deposits of Witwatersrand and Lydenburg.

VI. Sharply folded formations whose strata are nearly vertical will contain inter-stratified deposits, bedded or mass veins, like those of Swaziland and the "de Kaap" district.

VII. The auriferous horizons or reefs present the characteristics of strata so far as concerns the continuity of the deposit: and the features of veins as regards the dissemination of the gold. They may be said to be veins imprisoned between the strata.

VIII. Poverty of outcrop is not a sure proof of the poverty of a reef in depth or in its extension.

IX. By studying these ancient thalwegs or auriferous horizons it may be possible to discover new riches in South Africa.

X. The deposition of gold appears to be of Carboniferous age. It probably preceded that of Australia and was prior to the deposition of the Cape diamonds.

After gold, diamonds. Such is the geological emblem of the rich metalliferous countries of South Africa.

Paris, Mar. 7, 1896.

MINERALS AND THE ROENTGEN RAYS.

By W. G. Miller, Kingston, Ontario.

There are considerable differences in the opacities of minerals towards the Roentgen rays. This is best brought out, as shown in the accompanying cut (figure 1), from a photograph taken by the writer during February, in thin sections of rocks having about the requisite thinness for the ordinary examination under the petrographical microscope. If much thicker pieces of rock are used the different mineral grains interfere with one another and the results are indefinite.

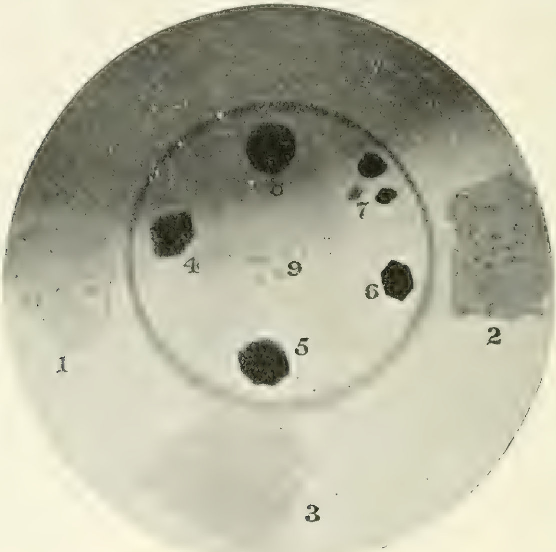


Figure 1.

In the figure numbérs 1 and 2 represent thin sections of granite in which the ferro-magnesian constituents are seen to be more opaque than the feldspar or the quartz. Number 3 is a thin section of hornblende gabbro in which the plagioclase is seen to be less opaque than the hornblende. Several minerals placed in a card-board box are represented in the centre of the figure. The circle shows the position of the rim of the box. Numbers 4, 5 and 6 are crystals of quartz, beryl and garnet, respectively, 7 three grains of corundum (ruby), 8 glass (imitation emerald), and 9 five fragments of diamond and one small grain of glass. The diamond grains are much thicker than the thin sections of rocks but are seen to be much more transparent. Carbon and its compounds, are in general, more transparent than inorganic substances. The presence of some other elements in compounds has a similar effect to that of carbon on their transparency, but to a less degree. Crystals of hydrated compounds appear to be generally less opaque than those of the corresponding anhydrous materials.

Besides having compared the relative transparencies of a large number of crystals, the members of the staff of this institution have examined a number of liquids. For this purpose equal volumes of the liquids were placed in small paraffin vessels of exactly the same dimensions. The differences in their transparencies proved to be very great. Sulphuric acid was found to be the most opaque of any of those examined and water the least so.

School of Mining, Kingston, March 23d, 1896.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Life, Letters, and Works of Louis Agassiz. By JULES MARCOU. (Two vols.; I, pp. xxi, 302; II, pp. ix, 318; with portraits and other illustrations. Macmillan and Co., 1896.) The foremost place among American investigators and teachers in zoology and biology, and one among the foremost of all the world in all time, must be accorded to Louis Agassiz. Before his coming to America, by his great work on fossil fishes, and by his adoption and earnest advocacy of the glacial theory of Venetz and Charpentier to account for the boulders and striation of Switzerland and of Scotland, Agassiz had made his most important contributions to the advancement of natural history and geology, and, in the opinion of his biographer, had attained the zenith of his life work. This may well be true in respect to the increase of knowledge by original investigations; but in the New World, from 1846 to his death in 1873, the great scientist continued to exert an increasingly powerful influence in the true work of the teacher, to discover and train students worthy to aid and finally to inherit wholly, and to carry forward unchecked, the work of the master.

The biography here published more than twenty years after his death, by the only survivor of the band of Franco-Swiss naturalists, Agassiz, Guyot, Lesquereux, and Marcou, who came to America at nearly the same time, deals chiefly with the scientific work, associations, friends and critics of Agassiz, with free and hearty praise and blame by the author himself. On the other hand, the reader must be referred to the biography by Mrs. Agassiz, to learn most fully the personal and social traits which endeared Agassiz to his wide circle of friends, to the common people, and especially to his pupils, who rarely failed to acquire an enduring enthusiasm for the natural sciences.

One of the conspicuous elements of the character of Agassiz, by which in his later years he was hindered and handicapped, namely, a strong reluctance to confess that opinions which he once had published were afterward found to be erroneous, Marcou believes to have been derived largely from the same disposition of Cuvier, with whom Agassiz had been intimately associated in his early years. Although the studies and discoveries of Agassiz in zoologic classification and in embryology gave the most convincing arguments, in the opinions of others and of nearly all his pupils, for the doctrine of organic evolution, as set forth by Darwin, this new light on the faunas and floras which Agassiz and Gray studied was not recognized by the former, while it was welcomed and advanced by the latter. On this subject, however, the biographer upholds Agassiz in his dissent against the origin of species by gradual evolution, so that some readers may wrongly infer that the question is still under discussion among biologists and geologists.

The boulder from the Aar glacier, which marks the grave of Agassiz, is shown in two views from photographs. More truly, and with equally peculiar fitness, his chief monument is the extensive Museum of Comparative Zoology which he founded at Harvard University. Again, in a most appropriate sense, another monument to his memory is the application of his name to the glacial lake Agassiz, the grandest of many belonging to its class in the Late Pleistocene history of our continent.

These volumes are a noble tribute to Agassiz by his friend. Appendixes note his many other biographies or sketches, mostly pamphlets or chapters or parts in larger works, his portraits, busts, medals, and tablets, and a complete bibliography of his writings. W. U.

A preglacial tributary to Paint creek and its relation to the Beech Flats of Pike county, Ohio. By W. G. TIGHT. (Bulletin of the Scientific Laboratories of Denison University, vol. IX, pp. 25-34, with map; Granville, O., Dec., 1895.) The large level tract called Beech Flats, which Prof. G. F. Wright has considered to be valley drift and alluvium deposited during the existence of a lake held by the barrier of the ice-sheet crossing the Ohio river at Cincinnati, is found to be an expanse of till or unmodified glacial drift, forming a part of the widely spread ground moraine. W. U.

Studies of Melonites Multiporus. By ROBERT TRACY JACKSON and THOMAS AUGUSTUS JAGGAR, JR. (Bull. Geol. Soc. America, vol. VII, pp.

135-170, Rochester, 1896.) The detailed observations made on the structure of the common echinoid from the Saint Louis limestone, *Melonites multiporus* of Owen and Shumard, forms the foundation of a more extended investigation of the Paleozoic forms in general. The species is first described at length. The results of the minute examination of the arrangement, and a consideration of the development, of the ambulacral and interambulacral plates are of special significance, showing clearly that there is great regularity presented and that there is a progressive introduction of ossicles in the non-porous fields. The pores in each genetal plate are regarded as normally three or four in number. In no case were the oculars found to be perforated. Careful research failed to reveal any evidence whatever of the madreporic character of any of the genetal plates, though the sieve-like nature of one of these plates has been clearly distinguished and figured by others. C. R. K.

Petrology for Students: An introduction to the study of rocks under the microscope. By ALFRED HARKER. (12 mo., 306 pp., with figures of rock sections: C. J. Clay and Sons, London, 1895.) The work is chiefly a description of rock structures and of classifications, the illustrations having been derived principally from British localities, yet with frequent reference to American authorities. The work must not be understood to deal largely with microscopic methods, nor with the crystallographic characters by which minerals are identified with the microscope. Given their identification, their grouping and appearances in the different kinds of rocks are detailed. It will make a very useful book for reference for all students who are familiar with microscopic methods.

N. H. W.

Geological Survey of Canada, Report on the area of the Kamloops map-sheet, British Columbia. By GEORGE M. DAWSON. (Pages iii, 427, with two large folded maps, seven plates [admirable views from photographs], and 17 figures [sections and sketch maps] in the text; forming Part B, of the Annual Report, vol. VII, new series; Ottawa, 1896. Price, 35 cents.) The area here described is square, measuring 80 miles on each side and comprising 6,400 square miles, situated wholly in the drainage basin of the Frazer river. The enclosing most eastern and western ranges of the great Cordilleran belt in British Columbia are referred, in their latest chief elevation, to the close of the Cretaceous period; but the intermediate Gold ranges are regarded as much older.

The interior plateau, within the Kamloops district, is now 3,500 to 4,500 feet above the sea; but during the middle and somewhat later portions of the Tertiary era it was probably reduced by stream erosion to form a low peneplain. Toward the end of the Pliocene period, however, this area appears to have been much uplifted. Concerning some of the changes which it has undergone, Dr. Dawson writes: "The great valleys by which the Interior Plateau is now conspicuously trenched—those of the Frazer, the Thompson, and their main tributaries—are relatively modern, being referable to the later part of the Pliocene Tertiary. This system of valleys is superposed upon an older one, believed to date from the earlier Pliocene, of which parts may still be traced meandering upon remaining blocks of the old plateau. Still older drainage systems, of which the streams took quite different courses, undoubtedly lie buried beneath the volcanic accumulations which are referred to the Miocene or middle Tertiary.

The drift deposits are very extensively developed, and their investigation opens many questions of great interest relative to changes of altitude of the land and methods of origin of the various formations.

Beneath the drift, the bed-rocks are of Miocene age (upper and lower volcanic groups), Oligocene (the Coldwater group), Cretaceous (the Queen Charlotte Islands formation), Triassic and Jurassic (the Nicola formation), Carboniferous (the Cache Creek series), and Cambrian (the Adams Lake and Nisconlith series), besides metamorphic and plutonic rocks.

Auriferous placer deposits of much importance are found in the valleys. During all the series of changes in the drainage of the region, the gold particles washed by the streams from the Cretaceous and Tertiary conglomerates and gravels have become gradually more concentrated in the gravels of the modern and present rivers, and these are the only placer beds which thus far have been worked. W. U.

Complete Geography. By ALEX EVERETT FRYE. (Pages 184, with an atlas of 24 page plates of maps.) *Supplement: The New England States.* By WILLIAM MORRIS DAVIS. (Pages 31, including larger maps of these states.) Boston, Ginn and Co., 1895. A most noteworthy feature of this new and excellent text book for schools is its profusion of instructive engravings from photographs, many of which are from the Gardner collection in Harvard University. Nearly all of these pictures are here used for the first time in a school geography. The grouping and relative areas of mountains, plateaus, and plains, on each continent, is displayed by so-called "relief maps," based on photographs of models. The geologic processes of elevation and subsidence producing continents, mountains, and ocean basins, and the agencies of erosion by which the lands have been sculptured to their present forms, are clearly although briefly characterized; and much attention is also given to climatic conditions and the causes of their diversity. These parts of the work were based on manuscripts of Prof. Davis; and in his description of New England, pupils are further taught not only in geography, but also in geomorphology and meteorology. The maps comprise one series in the text for illustration of the principles of the science, and for study with the lessons on successive regions; and at the end of the work, a second series, on a larger scale and with more details, is inserted for reference. W. U.

Summary Report of the Geological Survey Department [*of Canada*] *for the year 1895.* By GEORGE M. DAWSON, Director. (Pages 154; Ottawa, 1896. Price, 10 cents.) The expenditure for this survey during 1895 was $117.581.72, of which $18,400 were for printing and lithography. Twenty-six maps were issued, including fourteen sheets of the geological map of Nova Scotia on the scale of a mile to an inch. The general popular interest in the work of the survey is well indicated by the 26,785 visitors of its museum. Field work has been prosecuted by fourteen parties, of which two were in British Columbia, one in the Northwest Territory (boring 1,731 feet without yet reaching the petroleum-bearing strata at Athabasca Landing), one in Manitoba and Keewatin (exploring the country east of lake Winnipeg), four in Ontario, four also in Quebec, and two in Nova Scotia. Brief reports of the observations of these parties are presented, in which attention is especially directed to the economic resources of the several regions examined. W. U.

Studies of Palæechinoidea. By ROBERT TRACY JACKSON. (Bull. Geol. Soc. America, vol. VII, pp. 171-254, 7 plates; Rochester, 1896.) Of late years unusual activity has been shown in America in the detailed examination of the fossil echinoderms according to modern morphological methods. Instead of efforts being directed to the endless multiplication of species, as in most other groups, all energies have been bent towards inquiries leading to a better understanding of the structure and of the genetic relationships of the forms. Clark has already issued his first installment on the Mesozoic echinoderms, Wachsmuth and Springer have just completed the first part of their monumental work on the fossil crinoids, and now Jackson has appeared with a most welcome presentation of his studies on the Paleozoic echinoids, which have led to the proposition of an entirely new classification of the group.

The studies originated in a detailed examination of the structure of *Melonites*, the notes of which appear in another place. A few new species have been described, but the diagnoses are so complete and full of detail, and the comparisons with related forms so elaborate that one cannot but regret that the author's work does not include in its scope a similar treatment, in the same happy manner, of all of the known species, since so many of them are so poorly defined or almost unknown. The facts and theoretical considerations are carefully separated, the latter being brought out in the concluding paragraphs.

In regard to the taxonomic arrangement the author finds that a "natural systematic classification of Paleozoic Echini can be based on the features of the anatomy and development of the ambulacrum and interambulucrum and the relations of the peristome to the ventral border of the corona. While these features are the main ones, others are considered in the minor divisions of the group, such as imbrication of plates, the form of plates and the position of ambulacral pores. This classification, which is presented in tabular form, is distinctly intended as a systematic arrangement, in which the species, genera, families and orders are arranged so as to express their structural relations in a natural order. It is not intended as a phylogenetic table. While the phylogeny would probably follow somewhat similar lines, there are so many great gaps that it could not be stated that this is the true genealogical history of the group. In the table details of structure are given for each division from class to species, so that in this consideration of the table only additional and general features are discussed."

The arrangement of the Echinoidea, is as follows:

Subclass Euechinoidea.
  Order Cidaroida.

Subclass Palæechinoidea.
  Order I. Bothriocidaroida.
  Order II. Perischoechinoida.—Melonitidæ, Lepidesthidæ, Archæocidaridæ, Lepidocentridæ.
  Order III. Cystocidaroida.
  Order IV. Plesiocidaroida.

A list of nearly fifty of the publications alluded to in the text and the references given in three other works which are named furnish almost a complete bibliography of the Paleozoic echinoids. C. R. K.

Expedicion Cientifica al Popocatepetl. By J. G. AGUILERA and EZEQUIEL ORDONYEZ. (Comision Geologica Mexicana, 48 pp., 6 pls., with a geological section and map; Mexico, 1895.) This little tract, issued by the Geological Survey of Mexico, contains a history and a short scientific account of Popocatepetl, the highest peak on the North American continent with the exception of its rival, Orizaba. The volcano is snow-clad from its summit to a hight of about 4,300 metres. The description of the crater is one of the most interesting parts of the tract, the authors having been able to spend 28 hours upon and in it. They describe the crater as elliptical in outline, bounded by irregular sloping walls, and measuring in its long axis 612 and in its short axis 400 metres. Owing to the great irregularity in its margin the depth varies between 205 metres at the least to 505 metres at the greatest. The highest points in the rim have received distinct names,—Pico Major, El Portezuelo, El Espinazo del Diablo, and El Labio Inferior.

Popocatepetl is a cone formed by an accumulation of many successive currents of lava, covered with fragmentary materials, stones, sand, ashes, etc., and corresponds to those volcanoes called by some geologists "stratified cones." (P. 20.) The lower or older of these currents shows a rock structure more granular and less lustrous than that of the later ones. Polarized light also reveals a crystalline development in the former which is not found in the more glassy and amorphous structure of the latter. From these and other facts the authors deduce the conclusion that the history of the volcano has been marked by three stages which they denominate periodo cinerogeno, periodo brechogeno and periodo lavico. The earliest, the lava period, was the longest; during the second the ejecta consisted largely of pumice mixed at times with volcanic bombs,—blocks of andesite of the same nature as the lava; the third has supplied showers of ashes which overlie the older products and have been much eroded by wind and rain. These periods the authors correlate with the Pliocene, Pleistocene and Recent. Some of the earlier andesite lava flows are buried beneath beds containing remains of the horse and elephant, while a stream of very liquid basalt from the neighboring peak of Xitli overlies not only deposits containing vertebrate fossils but even human remains.

Three kinds of eruptive matter are defined,—labradorite-basalt, hypersthene-andesite and trachyte, of which the first is oldest and is found in the lowest currents; but the grand cone is mostly composed of the second, which varies in structure from holocrystalline to vitreous, while the little summits consist of the third kind of ejecta.

In the various facts given the authors see a record of the original great energy and gradual decay of the volcanic action which has now almost ceased, nothing but smoke and vapor issuing from the cone. Appended are a map and section of the volcano and several views of special points. E. W. C.

Notes on the Areal Geology of Glacier bay, Alaska. H. P. CUSHING. (Trans., N. Y. Acad. of Sciences, vol. xv, pp. 24-34, with map, Oct. 28, 1895.) Argillite rocks are found to occupy large areas about the eastern side of the Muir inlet and glacier. On Mt. Wright they have an exposed section more than 3,000 feet thick. The mountains adjoining the larger part of Glacier bay, however, consist of dark dolomitic limestone, which overlies the argillites, apparently conformably, and attains a thickness of several thousand feet. This is named the Glacier Bay limestone, and from its scanty fossils is regarded as probably of Carboniferous age. The strata have undergone much regional metamorphism, being tilted, folded, faulted, and fractured. Diorites, including one type containing quartz and another free from it, are present, and may be of later date than the Carboniferous sediments. Dikes, chiefly of diabase, cut all the foregoing rocks, and are younger than the time of their disturbance and metamorphism. These dike rocks much resemble others of known Tertiary age which occur farther south. W. U.

The Neocene Stratigraphy of the Santa Cruz Mountains of California. By GEO. H. ASHLEY. (Proc. Calif. Acad. Sci., ser. 2, vol. 5, pp. 273-367, pls. 22-25, 1895.) The first criticism occurring to the reader of this paper is that the author has sacrificed much of accurate observation and clearness of presentation to the somewhat natural zeal for covering a large area of interesting country,—a larger area than could very well be studied in the time at his disposal. The result has been to re-introduce into recorded California geology a certain amount of confusion, which, it had been hoped, was in a fair way to vanish, and incidentally, to call for an impartial criticism at the present time, in order that silence may not be construed as general acquiescence.

The introduction of the new term "Pescadero series" for the assemblage of rocks enumerated under that head, must be regarded as of very doubtful utility, embracing, as it is made to do by the writer, rocks that can be shown to belong to sharply different series, separated by conspicuous unconformities. In a previous paper on the Geology of the Coast Ranges* Prof. Lawson divides the rocks of the San Francisco peninsula into seven terranes, which comprise, in the order of their geological age:

1. *Crystalline limestone.*
2. *Granite*, intrusive in the crystalline limestone.
3. The *Franciscan series.*

*AM. GEOLOGIST, vol. xv, pp. 342-356.

4. A formation of light colored sandstone which is supposed, doubtfully, to be of *Tejon* (*Eocene*) age.

5. The *Monterey series* (*Miocene*).

6. The *Merced series* (*Pliocene*).

7. The *Terrace formations*, Pleistocene and later.

Prof. Lawson's descriptions show that there are at least two distinct horizons of limestone in the region under discussion,—a crystalline limestone that has been invaded by the granite (Gavilan limestone?) and a foraminiferal limestone which is interbedded with the rocks of the Franciscan series. It is accordingly a pure assumption to denominate all the limestone of the region as the "Gavilan limestone" and speak of it as though it were a single originally continuous bed, as is done by Mr. Ashley.

The San Francisco sandstone is described by Prof. Lawson as being the dominant sedimentary formation of the Franciscan series, and being interbedded with the foraminiferal limestone and radiolarian chert. A similar usage was followed by the writer of the present criticism in two earlier papers,* in the former of which the revival of Blake's old name was proposed. It is a matter of comparatively small import whether Blake did or did not originally include with this sandstone certain beds which later turned out to be Miocene, or that he referred the whole of it to the Tertiary. The fact remains that the term is an excellent one for the designation of a great mass of sandstones which are distinctly pre-Miocene but whose exact age is not yet fixed, and it possesses moreover the advantage of priority. The whole Franciscan series, according to Prof. Lawson, is separated from the lowest known Miocene by a long erosion interval.† Much of the sandstone which the writer of the paper before us has placed within his "Pescadero series" upon cursory field examination, such for example as the sandstone of Telegraph hill in the city of San Francisco, undoubtedly belongs with this older pre-Miocene series. Detailed field study and mapping of the Coast ranges teaches nothing more emphatically than that the correlation of the sandstones over any considerable area by superficial lithological resemblances is utterly futile.

In brief then, the "Metamorphics" of our author, duly corrected as regards the "Gavilan limestone," and increased by a portion of his "Pescadero series" corresponds with the well defined Franciscan series of Lawson.

Passing upward in the "Pescadero series" through unfossiliferous sandstones which may possibly be Eocene (compare No. 4 of Prof. Lawson's seven terranes), we reach, near the top, heavy beds of conglomerate containing Miocene fossils. This conglomerate is said to be made up of pebbles from the "Metamorphics," whose presence, as Mr. Ashley admits, it is not easy to account for "unless we assume considerable erosion previous to their laying down." As the conglomerates and underlying sandstones are apparently conformable in the cliff

*Bull. Dept. Geol. Univ. of Calif., vol. I, pp. 71-114 and 193-240.
†Am. Geologist, vol. xv, p. 354.

section of Pescadero, he concludes that "the uplift and exposure" preceding the deposition of the former "may have been local." It is scarcely necessary to point out that an apparent conformity in a single cliff section is but weak evidence for the general conformity of the two series when confronted by facts that point in the other direction. The legitimate conclusion would seem to be that we have here a basal Miocene conglomerate resting unconformably upon older sandstones. The main erosion interval would then mark the lower limit of the Miocene as we should naturally expect, and not be *within* the latter.

Although field work in other portions of the Coast ranges does not apparently preclude the possibility of the existence of one or more unconformities within the Miocene, yet in this particular case, the unconformity described between the Miocene shales of the Monterey series and the Miocene conglomerate just mentioned, would seem to require a little further demonstration, more particularly as the writer makes it depend mainly upon an alleged conformity between the Monterey series and the Merced series which there is very good reason to believe does not exist.*

The strongest evidence adduced in favor of a conformable relation between the Merced and Monterey series is the presence of so-called "transition beds" near the base of the former in the section along Seven Mile beach. The distinction between these beds and the undoubted Pliocene is made purely upon the evidence of the fossil remains, and, as the writer says, the drawing of the line of demarcation "would be largely governed by individual inclinations." Under the circumstances one may well express some doubt of the validity of drawing any line at all. He elsewhere refers to the present impossibility of correlating with absolute exactness, the Pacific Coast faunas with their nearest eastern equivalents, but nevertheless, employs just such rigid methods in this particular case. The paleontological discussion does not leave it at all clear that the fauna of the so-called "transition beds" is any less typically Pliocene than the series taken as a whole.

Successful correlation of deposits requires that there be taken into account not merely their faunal contents, but also the physical revolutions recorded by unconformities and sudden alterations in the character of the sediments. The general tendency of the paper before us is to under-rate the last two factors and to exalt the first. There is one rather startling reversal of this tendency, however, when a bed of white volcanic ash, averaging about a foot in thickness, which was noted by Prof. Lawson in the Merced series, is unhesitatingly correlated with the Miocene shale of the Monterey series, and used as evidence of a continuous sedimentation from Miocene times up into the Pliocene, and even into the Pleistocene.

"Transition beds" are also described near Santa Cruz as passing gradually and conformably into the Miocene. The author says, "As the bottom of the Transition beds is approached, the beds take on more and more the character of the white Miocene shale until before the

*Lawson, *loc. cit.*, p. 354.

parting is reached they become indistinguishable from it, showing that the conditions held over from one period to the other." It would be interesting to know in such a case just how the parting was determined and what was its character.

As concerns the base of the Merced series at Mussel Rock, and the possible existence of a fault there, it is sufficient to state that the observations recorded in the present paper and those previously published by Prof. Lawson are diametrically opposed, and that the earlier interpretation must be recognized as valid until more seriously attacked.

Throughout the paper Mr. Ashley lays great stress upon the frequency and importance of the faulting that the region has undergone. While willingly admitting a certain amount of conspicuous, and structurally very important, faulting, yet one is inclined to be somewhat sceptical over a super-abundance of convenient faults, and to prefer a suspension of judgment until they are brought out by detailed geological mapping.

Passing without criticism over the purely paleontological discussion at the end of the paper, and, as regards oscillations during the Quaternary, merely stopping to note that the two summaries of these movements given, are not strictly accordant, we revert to a subject that is frequently suggested by this paper, but which is, in addition, intimately connected with the greater part of the literature on California geology, —the misuse of the term *metamorphic*. This adjective, belonging to the petrographic side of geology, is properly applied to rocks whose constituents have wholly or in part undergone molecular re-arrangement, and have crystallized into new minerals, as in the crystalline schists, or to those which, consisting of a single chemical compound, have been rendered crystalline throughout, as in marble. Quoting from Geikie,* "metamorphism is a crystalline (usually also a chemical) re-arrangement of the constituent materials of a rock. . . . A metamorphosed rock is one which has suffered such a mineralogical re-arrangement of its substance." According to Dana† metamorphism is "a change in texture, crystalline structure, or mineral constitution." The word "texture" is somewhat ambiguous here, but is made clear by the context.

It was to be expected that the earlier geologists, before the introduction of modern petrographic methods, should have very frequently misapplied the word, as indeed they did—more particularly Whitney. It was less excusable that Becker should have not only continued but extended the misconception. But it is difficult to find a corresponding excuse for the reckless way in which rocks, particularly sedimentary rocks, are branded as metamorphic at the present day. Beyond certain local contact schists, which the writer before us does not mention at all, (and the Gavilan limestone, which should be excluded) the group of rocks which he has called the "Metamorphics" has not been shown to contain a single rock to which that adjective is certainly and properly applicable, as can be seen at a glance by referring to Prof. Lawson's description of the Franciscan series. It is possible that the serpentine

*Text Book of Geology, 3rd ed., p. 319.
†Manual of Geology, 4th ed., p. 309.

might be called " metamorphic " but it would be very doubtful propriety at best, and it would be far better to avoid the word in that connection, as being too thoroughly " polarized " and tending through its connotations to give an erroneous view of the origin of that rock. The same is true to an even greater extent with regard to the radiolarian cherts.

Prof. J. P. Smith in a recent paper* describes "The Metamorphic series of Shasta county." A brief inspection of his columnar section shows that he includes under that head over 6,000 feet of shales, soft limestones, shaly limestone, siliceous limestone, calcareous slates, argillites and tuffs, conglomerates, massive limestones and marbles. With the exception of the single mention of the word " marbles" there is nothing in the entire series that would lead a petrographer to characterize it as metamorphic.

In a paper just published† on the "Geology of eastern California," Mr. Fairbanks groups together rocks ranging from the Cambrian to the Triassic inclusive as a "Metamorphic series." Walcott has shown that in the White mountains (of this region) the Lower Cambrian is made up of arenaceous limestones, shaly limestones, siliceous slates and quartzites, with an aggregate thickness of 5,000 feet. It is probably true that the later rocks are no more altered generally than these ancient beds, except where intruded by granite. The advisability of massing them all in a "metamorphic series" certainly calls for reconsideration.

Other examples might readily be given, but these will suffice to show how unaltered rocks of many different ages have not only been referred to as *metamorphic*, but, worst of all, generally called "*the* Metamorphic series." When the term metamorphic is restricted to its proper use in Pacific Coast geology our views will become far clearer upon questions which have their own intrinsic difficulties, and are already sufficiently perplexing, without the additional obscurity that comes from inexact descriptions. —F. L. RANSOME.

A Summary of Progress in Petrography in 1895. By W. S. BAYLEY. (From monthly notes in the Am. Naturalist. Waterville, Me., 1896. Price 50 cents.) We are pleased to note the appearance of No. 14 of these useful summaries, which are too well known to require extended notice. An index of subjects, and also one of authors, has been added, thus increasing the convenience of reference. U. S. G.

*Journal of Geology, vol. II., p. 588.
†AM. GEOLOGIST, Feb., 1896.

RECENT PUBLICATIONS.

I. Government and State Reports.

Bull. N. Y. State Museum, vol. 3, no. 14, Sept., 1895. The geology of Moriah and Westport townships, Essex county, N. Y., J. F. Kemp. 33 pp., pls. 1-4, 2 maps.

Same, vol. 3, no. 15, Sept., 1895. Mineral resources of New York state, F. J. H. Merrill. 240 pp., 2 maps.

U. S. Geol. Sur., Geologic Atlas of the U. S. Folio 17, Marysville (California) folio, Waldemar Lindgren and H. W. Turner.

Geol. Sur. of Canada, pt. B, Ann. Rept., vol. 7. Report on the area of the Kamloops map-sheet, British Columbia, G. M. Dawson. Pp. 1B-427B, pls. 1-7, 2 maps, 1896.

Same, pt. M. Report on the surface geology of eastern New Brunswick, northwestern Nova Scotia and a portion of Prince Edward island, Robert Chalmers. Pp. 1M-149M, pls. 1-4, 5 maps, 1895.

II. Proceedings of Scientific Societies.

Bull. Geol. Soc. Amer., vol. 7, pp. 315-326, Feb. 25, 1896. Relations of geologic science to education, N. S. Shaler.

Same, pp. 327-348, pl. 15, Mch. 12, 1896. Preglacial and postglacial valleys of the Cuyahoga and Rocky rivers, Warren Upham.

Same, pp. 349-362, pl. 16, Mch. 14, 1896. Disintegration and decomposition of diabase at Medford, Mass., G. P. Merrill.

Same, pp. 363-376, pl. 17, Mch. 14, 1896. Geographic relations of the granites and porphyries in the eastern part of the Ozarks, C. R. Keyes.

Same, pp. 377-398, Mch. 23, 1896. Plains of marine and subærial denudation, W. M. Davis.

Trans. Kansas Acad. Sci., vols. 1-3 (1872), reprinted 1896, 135 pp. Coals of Kansas, W. H. Saunders; Limestones and coals (analyses), W. H. Saunders; Red sandstone of central Kansas, B. F. Mudge; Geology of Arkansas, B. F. Mudge; Recent discoveries of fossil footprints in Kansas, B. F. Mudge; Analysis of clays, W. H. Saunders; A geological survey of Kansas, B. F. Mudge; Brachiospongia, H. C. Hovey; Pliocene Tertiary of western Kansas, B. F. Mudge; Rare forms of fish in Kansas, B. F. Mudge.

Geol. Soc. of Washington, 1895. The origin of hypotheses: illustrated by the discussion of a topographic problem, G. K. Gilbert.

III. Papers in Scientific Journals.

Jour. of Geology, Feb.-Mch. Kame areas in western New York south of Irondequoit and Sodus bays, H. L. Fairchild; A pre-Tertiary nepheline-bearing rock, F. Bascom; Petalocrinus mirabilis (n. sp.) and a new American fauna, Stuart Weller and R. A. Davidson; Remarks on Petalodus alleghaniensis, C. R. Eastman; On the nature of igneous intrusions, I. C. Russell; Deformation of rocks, C. R. Van Hise.

Amer. Jour. Sci., April. The morphology of Triarthrus, C. E. Beecher; Examination of the arguments given by Neumayr for the existence of climatic zones in Jurassic times, A. E. Ortmann; Occurrence of theralite in Costa Rica, Central America, J. E. Wolff; Metamorphism of a gabbro occurring in St. Lawrence county, N. Y., C. H. Smyth, Jr.; Notes on Glacial gravels in the lower Susquehanna valley, H. B. Bashore; The Bearpaw mountains, Montana, W. H. Weed and L. V. Pirsson: Pleistocene marine shore lines on the south side of the St. Lawrence valley, Robert Chalmers; Occurrence of free gold in granite, G. P. Merrill.

Amer. Nat., April. The history and principles of geology and its aim, J. C. Hartzell, Jr.; Life before fossils, Charles Morris. The Paleozoic reptilian order Cotylosauria, E. D. Cope; Notes on the fossil Mammalia of Europe Pt. II—On the affinities of the genus Tapirulus, Charles Earle.

Science, Mch. 27. Current notes on physiography, W. M. Davis; The Philadelphia brick clays, R. D. Salisbury.

Science, Apr. 3. Expedition to Seriland, W J. McGee; The temperature of the earth's crust, Ellen Hayes; The prerogatives of a state geologist, Erasmus Haworth.

Science, Apr. 10. Naval erosion, G. W. Tower.

The Mining Bulletin, Mch. An estimate of geological time, W. A. Buckhout; Official geology, H. H. Stoek.

IV. Excerpts and Individual Publications.

The fauna of the Magnesian series (Description of fossils), F. W. Sardeson. Bull. Minnesota Acad. Nat. Sci., vol. 4, no. 1, pp. 92-105, pls. 5-6, 1896.

Ueber das Carbon des Mississippithales, C. R. Keyes. N. Jahrb. f. Mineralogie, etc., Bd. 1, pp. 96-110, 1896.

The Permian system in Kansas, F. W. Cragin. Colo. College Studies, vol. 6, pp. 1—48, Mch., 1896.

On the stratigraphy of the Platte series, or upper Cretaceous of the plains, F. W. Cragin. Ibid., pp. 49-52.

Preliminary notice of three late Neocene terranes of Kansas, F. W. Cragin. Ibid., pp. 53-54.

The nickel deposits near Riddle's, Oregon, W. L. Austin. Read before the Colo. Sci. Soc., Jan. 6, 1896; 27 pp.

Economic geology of the Mercur mining district, Utah, J. E. Spurr, with introduction by S. F. Emmons. U. S. Geol. Sur., 16th Ann. Rept., pt. 2, pp. 343-455, pls. 25-34, 1895.

Petrographical characters of some rocks from the area of the Kamloops map-sheet, British Columbia, W. F. Ferrier. Geol. Sur. Canada, Ann. Rept., vol. 7, pp. 349B-400B, 1896.

Greenland ice fields and life in the north Atlantic, with a new discussion of the causes of the Ice age, G. F. Wright and Warren Upham. xv and 407 pp., cuts and maps; D. Appleton and Co., New York, 1896.

Sur la météorite tombée le 9 avril 1894 près de Fisher (Minnesota), N. H. Winchell. Comptes Rendus, t. 122, no. 11, 3 pp., Mch. 16, 1896.

V. Proceedings of Scientific Laboratories, etc.

Bull. Dept. of Geol. Univ. of Cal., vol. 1, no. 13, pp. 363-370, Mch., 1896. Sigmogomphus le contei, a new castoroid rodent from the Pliocene, near Berkeley, Cal., J. C. Merriam.

CORRESPONDENCE.

THE GOLD-QUARTZ VEINS OF CALIFORNIA. In the March number of the AMERICAN GEOLOGIST, Mr. H. W. Fairbanks gives an interesting description of the gold veins of Inyo county and adjacent parts of eastern California. In this paper references are made to an article on the "Characteristic Features of the California Gold-Quartz Veins" which I published last year in the Bulletin of the Geological Society of America. As some of these references do not fairly represent my views, giving for instance the impression that no such process as replacement was recognized, only a filling of open fissures, it may be permissible to briefly indicate the manner in which I believe these deposits have been formed.

On page 153 Mr. Fairbanks finds that the conclusions reached in my paper do not at all apply to eastern California, citing especially the abundant occurrence of quartz veins in granitic rocks in that region. On the first and second pages of my paper I have, however, expressly excepted the deposits of Mono, Inyo and San Bernardino counties from the discussion, stating that they differ more or less from the normal type on the western slope. The following statements also only apply to the normal gold-quartz veins of the western slope of the Sierra Nevada.

The deposits are in all cases found along fractures and fissures which have a greatly differing character in different rocks and districts. In some cases there was only a crushed zone with extremely small interstitial spaces; again there may have been a crushed zone with larger openings between the fragments; or there may have been sharp, clear cut fissures often producing open spaces supported at frequent intervals by the closing walls. A fracture may change its character from an open fissure to a crushed zone in a comparatively short distance. These open spaces were seldom of great width, five feet being a rarely occurring measure. It is very probable, as Mr. Fairbanks remarks, that movement has frequently taken place along many fissures during the filling, and in such manner successive spaces opened for deposition. Along the mother lode some exceptionally heavy bodies of quartz occur, but to cite such dimensions as "fissures five to twenty feet wide and hundreds of feet in extent" (*loc. cit.*, p. 156) as representing California quartz veins is very far from the mark. There is nothing very improbable in the existence of open spaces at considerable depth; the way in which stopes in the deepest mines, in hard rock, often stand without support shows this plainly. There is of course a limit and below, say 10,000 feet, the open spaces are probably very small.

The solutions circulating in these fissures deposited silica, gold and metallic ores in the open spaces; simultaneously an active process of metasomatic replacement went on in the partly loosened and crushed country rock adjoining the fissures, by which it was transformed to a mixture of carbonates, sericite and iron-pyrites; usually all three of these minerals are present. Only in certain black, carbonaceous slates the former two are often lacking. This zone of altered rock is often of great dimensions, always contains some gold and may under certain favorable circumstances contain enough of the latter metal to be treated as an ore. The bulk of the gold is nearly always in the quartz filling the open fissures.

Mr. Fairbanks, while admitting that some veins may have been formed in open fissures, thinks that the process in most cases began by a crushed zone and that the vein matter was deposited as the solutions removed the crushed material, leaving at no time large empty spaces; great stress is laid upon the removal of material and the substitution by silica. According to my view no material has been "removed" bodily (excepting, of course, easily soluble rocks like limestone); there has only been an interchange of substance, a replacement of the rock forming minerals by carbonates, sericite and pyrite. The shape of the fragments, even their sharp edges, has often been preserved, only the composition changed. It is not denied that silica may have replaced certain minerals, but this process appears to me of very subordinate importance. Silicification of the wall rocks of the California gold-quartz veins has often enough been asserted; but as far as I know, not proved by chemical and microscopical investigation.

An absence of typical comb-structure does not prove the absence of open fissures. This comb-structure is frequently observed, but the "ribbon-structure" is more common. This latter may be of different origin; it may be caused by successive additions in open fissure through a long period of time; it may also be formed by additions to the vein on the outside by successive opening and tightening of the walls (*loc. cit.*, p. 155); it has also in many cases its origin in a dislocation and sheeting of the quartz vein subsequent to the filling.

Thus, in conclusion, I believe that the two processes—filling of open spaces chiefly by quartz and replacement of the country rock chiefly by carbonates and sericite—have proceeded simultaneously and are both of great importance. In the California gold-quartz veins the former process is accentuated because the richest ores have usually been formed by it. In other regions the filling of open spaces may be entirely subordinate, and the results of the replacement of the most economic importance.

WALDEMAR LINDGREN.

PERSONAL AND SCIENTIFIC NEWS.

MR. WARREN UPHAM is contributing a series of articles on the "Physical Features of Minnesota and the Northwest" to the *Northwest Weather and Crops.*

A CONGRESS OF MINING AND GEOLOGY will be held at Budapest on Sept. 25th and 26th, in connection with the Hungarian Millennial Exhibition which opens May 2nd.

TYNDALL'S "GLACIERS OF THE ALPS", first published nearly thirty-six years ago and for a long time out of print, has been reprinted by Longmans, Green and Co. of London.

MR. HARRY LANDES, professor of geology, mineralogy and mining in the State University of Washington, at Seattle, has been appointed by Gov. McGraw state geologist of Washington.

Mr. Warren Upham is visiting in New Hampshire and Massachusetts, during a short absence from his work as secretary and librarian of the Minnesota Historical Society, St. Paul, Minn.

A sketch of Henry A. Ward, the proprietor of Ward's Natural Science Establishment of Rochester, N. Y., is given by William T. Hornaday in the *Commercial Travellers' Home Magazine* for February.

Mr. Horace V. Winchell, of Minneapolis, who is well known through his papers on the iron ores of Minnesota, has consented to act as a corresponding American editor of the *Zeitschrift für praktische Geologie.*

"A Dictionary of the Names of Minerals, including their history and etymology," by Albert Huntington Chester, professor of mineralogy in Rutgers College, has recently been published by John Wiley and Sons.

Prof. N. H. Winchell, state geologist of Minnesota and managing editor of this journal, has spent the last year in petrographical and mineralogical investigation and study in Paris. He is expected home soon after the first of May.

Mr. Frank L. Nason, geologist and mining engineer, has gone to British Columbia to superintend the installation of the plant of the Columbia Hydraulic Mining Company of which he is the superintendent and engineer. (*Eng. & Mining Jour.*)

Dr. Harry Fielding Reid has been appointed associate professor of geological physics in the Johns Hopkins University, and he will give advanced instruction during the coming year along that line. It is planned to develop laboratory experimentation along physical lines of geological research.

The British Association for the Advancement of Science meets this year at Liverpool, Sept. 16th to 23rd, under the presidency of Sir Joseph Lister, president of the Royal Society. Mr. John Edward Marr is president of section C (geology). An attractive feature of the meeting will be a special scientific excursion to the Isle of Man.

Mineral Products of the United States for 1895. *The Engineering and Mining Journal* of April 11th contains a table (from advance sheets of "The Mineral Industry," vol. IV) showing the production of each mineral substance of economic importance for 1895, as compared with that for 1894; there are also brief statements concerning the more important of these substances.

The department of geology and geography of Harvard University has placed on exhibition in Cambridge the Gardner collection of photographs, which consists of more than 3,000 mounted photographs and about 1,500 stereopticon views of geological subjects and landscapes, mainly purchased from the income of a fund established in 1892 by George A. Gardner, of Boston. (*Science.*)

THE GEOLOGICAL SOCIETY OF WASHINGTON has recently (March) published a pamphlet of 44 pages which contains the presidential address of Mr. G. K. Gilbert, the constitution and standing rules of the Society, abstracts of meetings and lists of officers and members for 1895. There are 109 active and 43 corresponding members. Mr. Gilbert's address is entitled "The origin of hypotheses: illustrated by the discussion of a topographic problem," and is devoted to Coon butte, a volcanic crater of Arizona.

A MEMORIAL TABLET TO PROF. GEO. H. WILLIAMS has just been erected in the Williams room of the geological laboratory of the Johns Hopkins University. The tablet is the work of Mr. Murray of Philadelphia. It consists of a medallion likeness of Prof. Williams with the following inscription beneath:

> 1856. 1894.
> GEORGE HUNTINGTON WILLIAMS, Professor of Inorganic Geology.
> An eager student, a stimulating teacher, a tireless investigator, a loyal friend, who established and successfully promoted the study of geology in this University.
> This tablet is erected in loving remembrance by his parents.

CAPE OF GOOD HOPE GEOLOGICAL SURVEY. Last year a commission was appointed for the purpose of organizing, controlling and directing the work of geological exploration and survey of this colony. This commission has now appointed the following gentlemen to begin the work of surveying and mapping: Dr. G. S. Corstorphine, geologist; Messrs. A. W. Rogers and E. H. L. Schwartz, assistant geologists. As early as possible the commission will publish and distribute a bibliography of South African geology. The headquarters of the survey are at Cape Town.

GEOLOGICAL SOCIETY OF LONDON. The question as to the desirability of retaining the Museum of the Geological Society has formed the subject of long deliberations by the council of the Society. It was announced at the recent annual meeting that, in accordance with the report of a special committee, the trustees of the British Museum had been asked whether they would undertake to house and care for the collections, keeping type-specimens and specimens illustrative of papers read before the Society distinct, and defraying also the expenses of transference. To these conditions the trustees have assented, and the matter will before long be submitted to the Fellows for their decision at a special general meeting.

UNIVERSITY OF MINNESOTA, COLLEGE OF MINING AND METALLURGY. The sophomore, junior and senior classes of this college will spend the month of May in practical mining work on the Vermilion and Mesabi iron ranges of Minnesota. The latter two classes will leave Minneapolis on May 2nd, and the former on May 5th, returning May 31st. The party will first go to Soudan on the Vermilion range, where two weeks will be spent in the mines of the Minnesota Iron Company. Afterwards it is expected that about a week will be spent at Ely, and the party will return by way of the Mesabi range, stopping at some of the more important mines there. The work will be under the personal direction of Professors W. R. Appleby and F. W. Denton and Instructor Peter Christianson.

The Kansas Academy of Science, with headquarters at Topeka, has just issued a reprint of its "Transactions," volumes I, II and III. This society was organized on Sept. 1, 1868, as the Kansas Natural History Society. Four annual meetings were held under this organization, and on the fourth (Oct., 1871) the name of the society was changed to the Kansas Academy of Science. Volume I of the "Transactions" includes the papers of the fifth annual meeting (1872), and volumes II and III the papers of the sixth (1873) and seventh (1874) annual meetings respectively. A list of the geological papers in these volumes will be found under "Recent Publications" in the present number of this journal. The reprint was edited by the librarian of the Academy, Mr. Bernard B. Smyth.

The Mining Bulletin for March (published by the Pennsylvania College, State College, Pa.) contains two articles on geological topics by professors of that institution. The first, "An estimate of geological time" by Prof. W. A. Buckhout, differs in radical particulars from most papers dealing with the age of the earth. This paper argues for the view that the earlier ages of the earth were the short, and the latter the long ages, and the author concludes that several hundreds of thousands of years will cover all geological time and that it is even possible that 100,000 will suffice. The second paper is by Prof. H. H. Stoek and is entitled "Official geology." Sketches of the different organizations which have done geological work for the United States government are given, and reference is made to the work of the various state surveys.

Summer Courses in Geology at Harvard. These courses begin on July 3rd and continue six weeks. Three courses will be given in geology and two in physiography. The courses in geology are an elementary one, one in field work and an advance course in field work given by Profs. Shaler and Wolff. The first course in field work is under the charge of Prof. Shaler and Mr. J. B. Woodworth; lectures and discussions on the localities to be visited an dshort excursions in the vicinity of Cambridge will occupy the time of those taking this course to July 13th, and from that date to Aug. 3rd the class will engage in an excursion to many points of geological interest in Massachusetts and Connecticut. The courses in physiography, one an elementary and the other an advanced course, are to be given by Prof. W. M. Davis; these are intended especially for teachers of geography in secondary schools.

MARYLAND GEOLOGICAL SURVEY.

The legislature of Maryland in March passed a bill establishing a geological survey of that state. The Survey is under the direction of a commission composed of the following gentlemen: Lloyd Lowndes, governor; Robert P. Graham, comptroller; Daniel C. Gilman, president of the Johns Hopkins University; and R. W. Silvester, president of the Maryland Agricultural College. At a meeting of this commission held in Annapolis on March 25th DR. WILLIAM BULLOCK CLARK. professor of inorganic geology in the Johns Hopkins University, was appointed state geologist.

The Survey is planning first to take up the subject of building stones, and in this work will have the assistance of Prof. Geo. P. Merrill of the National Museum. At the same time geological mapping and other investigations will be carried on. The Survey will of course add largely to the field facilites which the students of geology in the Johns Hopkins University will enjoy, and it is intended that the work shall be largely done by them with the co-operation of outside experts on special points.

Ths bill establishing the Survey is entitled "An act to establish a state geological and economic survey, and to make provisions for the preparation and publication of reports and maps to illustrate the natural resources of the state, together with the necessary investigations preparatory thereto." The bill reads as follows:

"Be it enacted by the General Assembly of Maryland, that there is hereby established a State Geological and Economic Survey which shall be under the direction of a commission composed of the Governor, the Comptroller, the president of Johns Hopkins University and the president of the Maryland Agricultural College, who shall serve without compensation, but shall be reimbursed for actual expenses incurred in the performance of their official duties; and the said commissioners shall have general charge of the survey, and shall appoint as superintendent of the same a geologist of established reputation, and upon his nomination such assistants and employees as they may deem necessary; and they shall also determine the compensation of all persons employed by the survey, and may remove them at pleasure.

Sec. 2. And be it enacted, that the survey shall have for its objects: (1). An examination of the geological formations of the State, with special reference to their economic products, viz: building stones, clays, ores and other mineral substances. (2). An examination and classification of the soils and a study of their adaptability to particular crops. (3). An examination of the physical features of the state with reference to their practical bearing upon the occupations of the people. (4). The preparation of special geological and economic maps to illustrate the resources of the state. (5). The preparation of special reports, with necessary illustrations and maps, which shall embrace both a general and detailed description of the geology and natural resources of the State. (6). The consideration of such other scientific and economic questions as in the judgment of the commissioners shall be deemed of value to the people of the state.

Sec. 3. And be it enacted, that the commissioners shall cause to be prepared a report to the Legislature before each meeting of the same, showing the progress and condition of the survey, together with such other information as they may deem necessary or useful or as the Legislature may require.

Sec. 4. And be it enacted, that the regular and special reports of the survey, with proper illustrations and maps, shall be printed as the commissioners may direct, and that the reports shall be distributed or sold by the said commissioners as the interest of the state and of science demands, and all moneys obtained by the sale of the reports shall be paid into the state treasury.

Sec. 5. And be it enacted, that all material collected, after having served the purposes of the survey, shall be distributed by the commissioners to the educational institutions in such manner as to be of the greatest advantage to the educational interests of the state; or, if deemed advisable, the whole or a part of such material shall be put on permanent exhibition.

Sec. 6. And be it enacted, that the sum of ten thousand dollars annually, or so much thereof as may be necessary, is hereby appropriated out of any funds of the treasury not otherwise appropriated, for the purpose of carrying out the provisions of this act.

Sec. 7. And be it further enacted, that this act shall take effect from the date of its passage.

Geological Society of Washington.

At the regular meeting of the Geological Society of Washington, held in Washington, D. C., March 25, 1896, a paper was read by Mr. H. W. Turner on the

Archean Gneiss in the Sierra Nevada. According to the geologists of the Fortieth Parallel Survey, western Nevada is composed of a basement of Archean rocks, which throughout Paleozoic time formed a continental mass, the erosion of the eastern side of which furnished the material for the Paleozoic sediments of eastern and southern Nevada, while the erosion of the western side furnished the material of which the Paleozoic rocks of the Sierra Nevada are formed. On account of the intrusion, about the close of the Jura-Trias, of large masses of granitic rocks in the Sierra Nevada and the folding and crushing that occurred at this time, these Archean (?) rocks have been greatly obscured, and have not been recognized with certainty at a single point. However, in the cañon of the North Fork of the Mokelumne river, in the central Sierra Nevada, there is an area of gneisses having a maximum length of about nine miles, which are very similar to the gneisses of the Fundamental Complex (Archean) of the Lake Superior region. Associated with these gneisses is a biotite-granite which appears to be identical with the so-called Archean granite of the West Humboldt mountains in Nevada. The entire series, the gneisses and the biotite-granite, are certainly much older than the hornblendic granite or quartz-mica-diorite that lies to the east of the gneiss area. Dikes of the hornblendic granite penetrate the gneisses, and there are abundant gneiss fragments in this later granite. The gneisses are as thoroughly crystalline two miles from the granite contact as they are at the contact: and therefore their present gneissoid condition cannot be ascribed to the contact-metamorphism of the hornblendic granite. The relations of the gneiss series to the Paleozoic sediments of the Gold Belt on the west have not been made out. The gneisses are chiefly pyroxene-biotite-diorite-gneiss, hornblende-biotite-diorite-gneiss and quartz-biotite-diorite-gneiss. They are called diorite-gneisses because the feldspars are chiefly of the oligoclase-andesine series.

MR. WHITMAN CROSS read a paper on

The Diorite of Ophir Loop and its Inclusions, with suggestion as to the origin of certain gneisses. The diorite at this locality is a lateral arm of a stock which cuts up through Cretaceous sedimentary rocks and a bedded volcanic series of Tertiary andesites. The lateral offshoot from this stock is intruded as an irregular sheet between the Dakota Cretaceous and the upper Jurassic, reaching a thickness of 1,000 feet. In its lower portion it is locally very full of included rock fragments. These inclusions were described, and specimens were exhibited. They are interpreted as genetically connected with each other and with the diorite magma, which brought them to their present position.

The diorite is a variable rock, with augite and hornblende. The inclusions vary from feldspathic rocks, poor in dark silicates, to black amphibolites nearly free from feldspar. They are developed in granular and banded forms, and exhibit all manner of gradations in structure as well as in composition.

The study of these rocks led to the stated conclusions that quite local differentiation has gone on in the depths from which both diorite magma and inclusions came, and further, that a shearing movement of the differentiated magma, followed by consolidation, produced rocks greatly resembling many gneisses, amphibolites and schists. and especially those of the Archean complex. It was suggested that some gneisses and associated rocks of unexplained or assumed metamorphic origin may be primarily banded igneous rocks, which should be considered with their massive equivalents rather than with secondary schists of similar constitution.

The meeting of this society of April 8th was devoted to a general discussion of the subject of the application of stratigraphy and paleontology in determining subdivisions of geologic time.

The broad problems involved in the announced topic were primarily presented by MR. WHITMAN CROSS in a concrete case. He described the present state of knowlege regarding the formations of the Rocky Mountain region belonging to the periods between the marine Cretaceous and the Wasatch Eocene, including the Laramie, Arapahoe, Denver, Ft. Union, and Puerco. The stratigraphic relations as at present known were described and then the facts of the fossil floras, the invertebrate and the vertebrate faunas were summarized. From the facts given it appears that the geologist investigating the formations of the group named is confronted by much conflict of evidence as to the relative importance of the time intervals separating the epochs of sedimentation. This is especially true in respect to the drawing of a line between the Mesozoic and Cenozoic in this region. The conflict of evidence in this instance was cited to show the necessity for a careful examination as to the nature of the connection between great faunal changes and the contemporaneous events of stratigraphic history. It appears that all forms of life were able to survive without radical change the period of great orographic disturbance at the close of the Laramie proper, and that the dominant vertebrate life of the post-Laramie disappeared at the close of that epoch from causes as yet unknown, which did not effect in any corresponding degree the contemporaneous plant and invertebrate life.

MR. F. H. KNOWLTON presented a review of the fossil floras of the Laramie, Arapahoe, Denver, and Ft. Union formations, showing the strong distinctive characters of each and also their intimate relationship. This evidence fails to indicate any one break of supreme importance in this series of epochs.

Mr. T. W. Stanton reviewed in a similar manner the known invertebrate life of the upper Cretaceous and Lower Eocene deposits of the Rocky Mountain region. The termination of true marine conditions was deemed to be the only safe criterion from this evidence to be applied in drawing a boundary for Mesozoic time.

A comparison of the vertebrate faunas of the post-Laramie, Puerco, and Wasatch formations by Prof. W. B. Scott, of Princeton, was read by Mr. Cross. This brought out the remarkable differences in the vertebrate life of the three epochs and also the impossibility of explaining the abrupt changes in these faunas from our present knowledge of attendant conditions.

Mr. F. V. Coville gave a review of the conditions affecting the distribution and changes in living floras, starting with the great controlling factors, heat and moisture, and making suggestions as to the applicability of these data to geological history.

Dr. C. Hart Merriam similarly described the conditions most effecting the distribution or causing modifications of terrestrial vertebrate life of the present, and discussed the apparent application of these facts to the past.

Mr. Bailey Willis referred to the variable relations which might exist between angular unconformity and otherwise important stratigraphic breaks.

Mr. R. T. Hill briefly referred to the development of knowledge of the lower Cretaceous series of Texas, to which he had given twenty years study, bringing out facts that bore in a general way on the subject under discussion. W. F. Morsell.

Academy of Natural Sciences of Philadelphia.

The mineralogical and geological section met on April 7th.

Mr. Jos. Willcox described the process of obtaining quartz from the Oriskany sandstone of Pennsylvania to be used in the manufacture of glass. Mr. Keeley stated that the bed used for the purpose extends southward through Bedford county, where the material can be used without crushing, as it crumbles when exposed to the air. Prof. Carter suggested the use of the stone from the Conshohocken quarries as a source of silica. When treated with hydrochloric acid the stone yields flattened transparent grains of silica, not at all colored by iron. The percentage of mica is small, the glistening appearance of the rock being due to the presence of the quartz.

Mr. Geo. Vaux, Jr., called attention to recent additions to the William A. Vaux collection which included superb crystals of calcite from the Joplin region, Missouri. They occur in caves opened for the working of lead and zinc. The several mines are characterized by distinct forms of the mineral. The sphalerite, which is largely present, is being deposited at the present time, the handles of shovels and picks left in the mines being found covered with crystals.

Mr. Theodore D. Rand described a fine collection of rocks from numerous localities in southeastern Pennsylvania. They belong to two groups, one bordering the ancient gneiss, the other and the more recent occurring in the mica schists and gneisses. The former are altered igneous rocks, either crysolitic of pyroxenic. The sources of the several forms were traced.

Dr. F. Bascom reported that thin sections of the serpentine, from the belt in which the La Fayette and "Blue Rock" quarries are situated, showed that the rock was originally a peridotite. Olivine grains still remain, exhibiting the characteristic alteration, along a network of cracks, to serpentine. The alteration in many localities is carried farther, resulting in the formation of a *perido-steatite*. She also reported that the Conshohocken trap dike is a typical diabase, still comparatively fresh and possessing both the constituents and structure of that rock-type. Edward J. Nolan, Rec. Sec'y.

Figure 1.

Figure 2.

LOG-LIKE CONCRETIONS, FROM THE LARAMIE FORMATION, EWING CO., S. D.

THE

AMERICAN GEOLOGIST

Vol. XVII. JUNE, 1896. No. 6.

LOG-LIKE CONCRETIONS AND FOSSIL SHORES.

By J. E. Todd, Vermillion, S. D.

(Plate XII.)

During the past season it was my privilege to visit the Laramie formation of western Dakota about the head waters of the Grand and Moreau rivers. The formation is composed of alternations of sand, often passing into yellow loam resembling loess, with drab-colored clays and beds of lignite. The sands are in places hardened into massive sandstone, but are more frequently incoherent. My attention was called, in my earlier acquaintance with the formation, to peculiar elongated concretions lying in the beds of sand. These were particularly conspicuous about prominent points of the landscape. One of the first views observed is shown in plate XII, figure 1. It represents a series of these concretions extending a distance of 100 feet and lying in strict order end to end. On either side others are seen less regularly arranged with their axes approximately parallel. Closer examination revealed the fact that they are composed of fine sand cemented together with calcareous matter and showing wavy lamination or ripple marks. The separate blocks or segments are separated by square joints, except at the ends of the series, where they are rounded. One block at the locality especially attracted my attention. It was about twelve feet in length and two feet in diameter. When viewed from one side it had the exact appearance of a saw-log with the bark removed and the ends flat as if cut with a saw. The wavy lamination imitated closely the curly grain sometimes seen in wood. Further acquaintance with the region showed like phenomena very common. In cut banks more or less transverse to the axes of the concretions they were seen to project like logs from a flood deposit.

Some of the variations observed are the following: Sometimes these concretions are only a few feet in length with rounded ends, and occasionally, where their length equals their diameter, they become globular. Sometimes there is a repetition of the log-like feature in a lateral direction, and they are often cemented to each other. Plate XII, figure 2, shows an example of this sort. At other points this variation passes into a regularly formed stratum of sandstone of limited extent. Though often showing almost perfect cylindrical form, more frequently their form and surface are somewhat irregular. They commonly show more or less iron present, as is indicated by their rusty appearance. Sometimes this is sufficient to make them black. No fossils were found in them at any time. They are sometimes associated with concretions of the more common biscuit-shape. The sizes more commonly represented are from one to two and a half feet in breadth, while the sections separated by joints are from two to five feet in length, and the series lying in very direct course sometimes attained a length of 100 or 150 feet. Not only is there the tendency of repetition in a lateral direction but also in a longitudinal. While any one system rarely exceeds a breadth of two rods, the length sometimes may be measured by miles. Not infrequently by climbing to the top of a conical hill and ascertaining the direction indicated by the axes of the concretions, the system can be traced for miles on the same level. These longer series frequently show curves and sometimes angles. Sometimes in the same hill several series may be noted, one above another, which commonly show different directions for their axes.

So far as I am aware this is the first time that attention has been called to these novel formations. Opportunity did not permit me to make a systematic or exhaustive study of them, but it seems not improbable that some such explanation as the following may be established. The concretions are unlike those below in the Fort Pierre formation in form, substance and arrangement. Their most surprising feature is the elongation of the concretions and this in a uniform direction. These features can scarcely be traced to a difference in permeability of the imbedding formation in different directions. Moreover the initiative influence causing them must have been of wide extent. Nothing has seemed more rational than to suppose these systems of concretion mark ancient beaches, and that the determining influence for their consolidation lay in the segregating effects of wave action. We can easily conceive that the sand, upon the ancient shores, was thrown into small ridges parallel with the edge of the water. There would be a differential accumulation of fine material between the ridges, not only from the action of the waves but from the motion of rains and the effect of winds. Here also organic matter would be likely to accumulate and this might be sufficient to determine the centers for concretionary action: and so the log-like concretions which we have described may be traced to the influences attending the ancient shores of the Laramie lakes. It is not improbable that further study may enable us to map out the shore lines of the bodies of fresh water attending the different stages of the Laramie formation. It seems probable that fossils may be found preserved in these deposits, although none were collected during the past season.

This discovery opens up an interesting and novel field of investigation of other formations. Circumstances, however, may not have been so favorable for the formation of such concretions upon marine shores because of tidal fluctuations.

THE ANCESTRY OF THE UPPER DEVONIAN PLACODERMS OF OHIO.*

By E. W. Claypole, Akron, Ohio.

The remarkable fish fauna which suddenly appears in the Upper Devonian shales of Ohio furnishes an illustration of a principle that has now become familiar to the paleontologist.

*The substance of this paper was delivered before the Ohio State Academy of Science at its annual meeting at Cincinnati in December, 1895.

He is accustomed to find new and strange forms of life suddenly appearing on the theatre being, having no evident connection with the fauna before them and in like manner leaving no discernible traces in the fauna that followed them. Illustrations of this principle might readily be found and quoted. They indicate gaps in the line of development, local breaks in the chain of life, unsolved problems in evolution.

No evolutionist, however, believes for a single moment that any real break occurs in the series or that the genetic connection has ever been interrupted. He prefers to attribute the apparent gap to the imperfection of the geological record whose deficiencies are only too well known. Whole volumes of this record are as yet unfound and others have no doubt been completely destroyed. But in spite of loss and ignorance the induction is so vast that to adopt the opposite conclusion would be illogical.

The placodermic fauna of the Upper Devonian Black shale consists of about ten species of *Dinichthys*, four or five of *Titanichthys*, one each of *Brontichthys* and *Gorgonichthys*, with *Coccosteus*, *Mylostoma* and a few other less known forms. Their great number and large size are sufficient to render them remarkable, but the suddenness of their appearance and disappearance is yet more striking. In both these respects they parallel the great fishes of the Old Red sandstone of Scotland which the labors of Hugh Miller have rendered classic.

The Cleveland shale is a comparatively thin stratum, seldom exceeding fifty feet in thickness in northern Ohio. It is black and very smooth and soft. But embedded in it are numerous concretions in which the fossils occur. These concretions are somewhat calcareous, very hard and heavily charged with iron pyrites. The fossils themselves are loaded with the same mineral, not by its substitution for the original phosphate of lime but by its deposition in the Haversian canals of the bone which it entirely fills. Under the microscope thin sections show the translucent bony structure and the perfectly opaque pyritous filling with perfect distinctness.

The various species are not indiscriminately scattered even through this thin stratum. Their distribution, generally speaking, is nearly as shown below, at least in the district around Berea where they are best known.

CLEVELAND SHALE.	16'	*Dinichthys terrelli* *Gorgonichthys* *Titanichthys rectus*
	8'	*Dinichthys intermedius* *Titanichthys*
	15'	*Dinichthys intermedius* *Coccosteus*
	8'	

Only two stations have yet been worked, so that our knowledge of these remarkable forms is very restricted, and we may reasonably anticipate great additions to the number of species and to the details of their anatomy when more workers are in the field and a wider region is searched.

But with every addition to this marvellous fauna its sudden emergence only comes into more striking prominence by contrast with the barrenness of the rocks immediately underlying the Cleveland shale. Whatever views may be taken of the general relations between these two the fact remains that in northern Ohio only a few feet of sediment separate the greenish Erie, in which no fish remains occur, from the black Cleveland shale with its rich ichthyic fossil fauna. It is a step from death to life. So far as is yet known the latter consists of the following species:

Dinichthys	9 species	*Brontichthys*	1 species
Titanichthys	4 "	*Glyptaspis*	1 "
Gorgonichthys	1 "	*Diplognathus*	1 "
Coccosteus	1 "	*Mylostoma*	2 "
		Trachosteus	1 species

The contrast of these 21 species from the Black shale with the total absence of fish fossils from the greenish shale immediately below it is striking, and of itself is sufficient to mark some great change in the conditions of deposition. What these were we cannot just now explain.

Alongside of this remarkable fish fauna must be placed an almost total lack of every other organic trace. In the smooth shales and in the concretions alike the discovery of any other fossil is an exceedingly rare event. In all his years of work Dr. Clark has shown me only a half dozen specimens besides fishes. These consist of a lamellibranch shell, *Eodon bellistriatus*, and a few small fragments of *Lepidodendron* sp?. Dr. Clark's son has also found two specimens of a cephalopod very closely resembling *Gyroceras undulatum*, but probably different. It is not yet described.

It is not easy to say whether this almost absolute dearth of invertebrate fossils is due to an actual scarcity of invertebrate life or to the subsequent destruction of shells or other calcareous material by infiltrating water through strata almost devoid of carbonate of lime. It seems wiser to prefer the former cause, as in the latter case impressions would probably be left though the fossils were dissolved, as has happened in so many cases elsewhere. Moreover, even the few mollusks that remain have lost all their calcareous matter and had others existed there would seem to be no reason why they too should not have left at least some trace of their former presence. The cause of the absence of invertebrates must be sought in the conditions of the environment.

But the almost absolute barrenness of the Erie shales is more puzzling. Long days of labor in this stratum will in all probability be rewarded with nothing more than a small handful of broken specimens or a few indistinct impressions, and these only in certain stations. This shale, whatever view we may take of its relations, is in Cayahoga county at least 300 feet in thickness. Eastward the mass increases rapidly until in the eastern part of the state it reaches at least 2,000 feet, while westwardly and southwardly it thins away to a feather edge and disappears. To the eastward, moreover, it must be further noted that the Black shale is not found and in mid Pennsylvania and New York the whole body of the Chemung—the equivalent in part of the Ohio shale—takes on the same greenish hue.

The most natural explanation of these facts is that the Black shale marks the shallow portions of the Appalachian gulf where vegetable and animal life was present but where no great volume of sediment was brought in from the adjoining land, while the thicker and barren greenish shale to the eastward marks an area of deeper water where sediment was abundantly deposited, while at the same time conditions did not allow, save locally and temporarily, the formation of limestone as in an open sea.

Furthermore, it may be noted that the fishes of the Upper Devonian of Ohio and those of the same era on the opposite side of the Appalachian gulf in New York and Pennsylvania are of totally different species. Few or none of either coast passed over the intervening depths to the opposite shore. The fauna of the New York Catskill and Chemung differs entirely in species from that of the Cleveland Black shale, though they were more or less closely contemporaneous. We are hence led to the inference that these great placoderms were shore-haunting or estuarine fishes, frequenting the mouths of rivers and the adjoining seas or possibly ascending the streams themselves like the mud-fishes of the present day. To such creatures the deep seas are barriers as impassable as the dry land. In the shore muds of the Appalachian gulf therefore—the black shales of the present day—their remains may naturally be sought and here it is that they are found.

Below the barren Erie shales we find in central Ohio another black bed sometimes 300 feet in thickness and so closely resembling the Cleveland shale that the two can be distinguished with difficulty, if at all. In the lower shale we come upon another fish fauna consisting of a few kinds more or less like those of the upper shale, but all specifically different. The following described by Dr. Newberry are all that we yet know:

Dinichthys hertzeri	*Callognathus serratum*
Goniodus hertzeri	*Onychodus ortoni*
Callognathus regulare	*Aspidichthys clavatus*

Here is a group of fishes, one of which is so closely allied to the larger genus in the Cleveland shale that it bears the same name, *Dinichthys*. The paleontologist sees in this a proof that the genus continued to exist all through the succeeding barren interval, but that either its relics have been destroyed or that these fish left the area for a time and returned to it later. Which of these explanations must be adopted in the present case we shall show below.

There is an easy way of connecting these two faunas. I have said that the Erie shale thins away to nothing, thus letting one of these black shales down upon the other in the central and southern part of Ohio. Here then we can read an uninterrupted history and can trace the connection between *Dinichthys* of the lower and *Dinichthys* of the upper Cleveland shales, and the ancestry of our Upper Devonian placoderms is found in their Middle Devonian predecessors.

The interpretation is, therefore, that during the continued depression, which allowed the accumulation of the thick barren shale in Ohio and Pennsylvania, the Black Shale region was one of comparative stability where the succession of life went on unbroken but not unchanged. Consequently the time interval represented by the massive strata between the Corniferous and the Carboniferous of the east, sometimes reaching 15,000 feet, is not longer than that which is represented in central Ohio by the 300 or 400 feet that occupy the same taxonomic position in the geological column. Sedimentation in the former case must have proceeded very much more rapidly than in the latter.

Descending again we find the lower shale and its fish fossils underlain by the Corniferous, etc. limestone. This which forms the Devonian floor of the eastern half of the state is about 80 feet thick and also contains fossil placoderms. But we have in our downward progress now lost our clue. Among the placoderms is no *Dinichthys* or any genus already seen. They consist of the following:

Acantholepis pustulosa?	*Rhynchodus secans*
Acanthaspis armata	" *frangens*
Macropetalichthys sullivanti	" *crassus*
Asterosteus stenocephalus	*Dinichthys ? præcursor*

Coccosteus occidentalis

It is true that the name *Dinichthys* appears in the above list, but its generic identification is very doubtful and no reliance can be placed upon it for the purposes of argument. We encounter then at the top of this limestone a complete paleontological ichthyic break. No species and no genus crosses the line. Obviously the ancestor of *Dinichthys* must be sought elsewhere. *Macropetalichthys* was, so far as can be determined, a toothless species and very far from what a probable progenitor of *Dinichthys* might be expected to be, while *Onychodus*, though toothful enough, is built on a type totally different from that of the great Upper Devonian placoderms.

Reflecting for a moment on the conditions of the era, into which space will not allow us here to enter, we find that the probable cause of the change in the Ohio area at the end of the Corniferous period was due to the uplift of a great region in the northeast whose wash was sent down into the Appalachian gulf, causing mechanical deposit to take the place of the previous calcareous mud and at the same time cooling down the Corniferous sea, and so rendering it less fit for the growth of corals. *Onychodus* and its companions were fishes of the open clear sea and probably left the region when the waters no longer suited them, so that for the ancestor of the Upper Devonian fishes we must seek some area where congenial conditions existed, that is to say, some Corniferous shore lines. But such shore lines are yet scarcely known in eastern North America, and have apparently been very largely destroyed.

Here then is the first gap in our history. One volume at least is missing, and from Ohio we learn nothing more. Our state record is a blank touching vertebrate life before the days of the Lower Devonian limestone. Fishes appear in the Ohio waters fully developed, and for the earlier stages of their development we must look elsewhere.

Many facts which cannot be detailed here, as they would unduly lengthen this paper and divert our attention from the main issue, lead to the belief that very great geographical changes took place in the Ohio region during the Devonian era. Especially about the middle of that era do we find evidence of such changes. Prof. H. S. Williams drew attention to one phase of this subject in his address to the geological section of the American Association for the Advancement of Science at Rochester in 1892. Another phase is indicated by the present topic. During the early Devonian era facts render it probable that the sea of western North America and the Appalachian basin were separated by a land barrier. The different aspect of the two faunas does not admit a free and open waterway from one area to the other. But about the middle of the era there is an intrusion of new forms into the latter which have apparently immigrated from the former. The facies of these strange species is not Appalachian, but rather European and induces the belief that an ocean extended over the northwest and thence to Europe, and that this ocean had been the previous home and origin of the intruding species. Now on this view it would be easy to refer the sudden appearance of the dinichthyids to the same cause and, though the data regarding vertebrates are yet exceedingly slender, yet the presence of *D. canadensis* in Manitoba and of

D. eifelensis in Belgium (Eifel limestone) are facts which very strongly favor such a reference.

If we succeed in proving a connection between the waters of northwestern America and those of Europe in the earlier part of the Devonian era and a further connection with the Appalachian area in middle and later Devonian time, we must forthwith look in Europe or Asia for the ancestors of the Ohio placoderms. And the evidence there attainable is very significant. Great fishes of similar character have been found and described from Russia and Bohemia in rocks of equal age with those of Ohio and in some instances of greater antiquity. No species is identical, but the general character of the fauna is such as to leave no doubt of its taxonomic relations. The great Middle Devonian limestones of the Eifel (Belgium) and the Baltic governments of Russia, all more or less contemporaneous with part of the Scottish Old Red sandstone, contain a wealth of fish fossils which the labors of Pander, Schmidt and others have made known to the paleontologist. Here occur *Asterelepis*, *Bothriolepis*, *Holoptychius*, *Dendrodus*, *Pterichthys*, with *Coccosteus*, *Homosteus* and *Heterosteus* and others more or less closely related to the Ohio forms, and in this region apparently must we seek the ancestors of the latter.

But here we encounter another break. The Lower Devonian rocks do not occur in Russia, but the "middle Old Red sandstone reposes transgressively on various members of the Silurian rocks."*

To Scotland and England we must turn for the missing chapter in the history, where in the Caithness and Forfarshire flags and Herefordshire cornstones and tilestones of the lowest Devonian a fauna occurs deeper in position and older in time than any of those already mentioned. But from this fauna all the great placoderms are absent and their place is occupied by smaller fishes of strange structure and uncouth appearance. *Pteraspis*, *Cephalaspis*, *Auchenaspis*, etc., characterize this zone, few of them exceeding a length of twelve inches. They present in general the placodermic structure in that their fore parts were encased in bony armor, while their hind parts possessed no such protection. It is true that none of the previously mentioned species are found accompanying these

*Murchison. "Siluria," 1859, p. 381.

older forms, from which we must infer the absence of some volume of the records intermediate between that found in Russia and this earlier one from Great Britain. These are yet to be sought and probably found elsewhere.

But in spite of this still existing gap the paleontologist is warranted in his deduction that the two faunas, the Middle Devonian of Russia and the Lower Devonian of Scotland and England, are genetically connected and that only further search is needed to bring the records to light and complete the genealogical tree of these early fishes, waiving of course the possibility that the volume has been wholly destroyed.

No difficulty is encountered in taking the next step. In this we cross the frontier between the Devonian and Silurian systems. In the uppermost beds of the latter, which in England lie conformably under the lowermost Devonian strata, we find fish remains in great abundance of the same type as those last mentioned, but of different species. *Cephalaspis* is no longer seen, but *Pteraspis* and one or two kindred forms represent the fishes and are so like those of the lowest Devonian tilestones immediately over them as to leave no doubt of their relationship. The upper and lower Ludlow shales contain this early record of ichthyic life; the former abundantly, but the latter has as yet yielded a single specimen of *Cyathaspis* (*Scaphaspis*) *ludensis* to show that at that remote date fishes had come upon the stage of being in the English seas. But of any earlier forms no British evidence is forthcoming. The Llandovery shales and sandstones with *Pentamerus oblongus*, the taxonomes of the Clinton of New York, have yielded no trace of fishes.

Returning now for a moment to the Russian area we find some indications that *Cephalaspis* was there of rather earlier date, for in strata in the Isle of Oesel, which yield the common English molluscan fossils of the Ludlow rocks, Eichwald reports a *Cephalaspis* (*Thyestes verrucosus*) whose congeners do not appear in England until we rise to strata characterized by their Mollusca as Devonian. But in spite of this the English Lower Ludlow with its solitary *Cyathaspis* (*Scaphaspis*) is seemingly the very lowest horizon to which in the Old World fish fossils have been traced.

Even here, however, our investigation does not altogether fail, for within a few years the clue has been found again on this side of the Atlantic and in Silurian strata of probably somewhat greater antiquity than any of those already mentioned. But in entering on the details of this last chapter in our story it will be well to dwell for a moment on the physical conditions of the time. I have pointed out the fact that in Lower Devonian periods communication was interrupted between the European and the Appalachian seas. But in the earlier (Upper) Silurian era this communication was at least comparatively free. Evidence of this is found in the great number of species that are common to the two areas. The passage-way of the communication may have been direct, that is over the present Atlantic, or it may have been circuitous across western America and Asia. In either case the demands of paleontology will be satisfied.

In 1883 the writer, while examining some beds of sandstone and shale in Perry county, Pennsylvania, discovered many specimens of fish remains which on further study were found to be closely related to the pteraspids of the English Ludlow beds and evidently represented the same family, which had not been previously recognized on this continent. They were described by him under the name of *Palæaspis** and scarcely differ except in minor details from their confamiliars of Europe. Their presence in the Appalachian area can be explained by the recognition of a water communication as above shown. But the stratum in which they occur is probably lower than that in which the oldest of the English pteraspids is found. The relationship may be shown as follows:

English	Appalachian
Ludlow, upper	Lower Helderberg
" lower	
* * * * * * * * *	Onondaga, Salina
Wenlock	Niagara

The Ludlow beds are correlated by their fossils with the lower Helderberg of North America. But no gap is known to exist in England between these and the Wenlock beneath them, which are on indisputable evidence correlated with the Niagara. In Appalachia however the thick colored marls of

*Quart. Jour. Geol. Soc., 1883.

the Salina with beds of rock salt intervene and are at least 1,000 feet in mass. In these were found the shields of *Palæaspis* in great numbers. They are consequently of equal age, to say the least, with the pteraspids of the Ludlow, all the yet known specimens of which except one solitary shield of *Cyathaspis* (*Scaphaspis*) *ludensis* have come from the upper division.

This discovery enables us to trace the genealogical tree a little nearer to its root, but even this does not bring us quite to the point where the clue is completely lost, for in a hard but thin sandstone bed considerably deeper down the writer soon afterward found crushed, broken and incomplete specimens of ichthyic organisms which enabled him to carry the history of the vertebrates almost to the base of the (Upper) Silurian system. The sandstone in question lies toward the base of the Clinton rocks and hence the fossils are older than those last mentioned by all the time represented by the base of the Salina, the whole of the Niagara and most of the Clinton, or at least 1,000 feet of deposit in the region where they occur. Some of them show the peculiar markings of the pteraspidian shield and are accompanied by numerous pellets of phosphatic matter, seemingly coprolitic, which lend further confirmation to the discovery. These afford indications of elasmobranch fishes.

Lindström has recently carried the history of the pteraspidians in Europe to an earlier date by his description of a *Cyathaspis* from the island of Gotland found in a stratum whose nearest equivalent is the English Wenlock shale. His paper in the Annals of the Royal Swedish Academy appeared after this article was written. By this discovery the Sweden pteraspidians are carried back to an earlier date than any yet found in England.*

*Two claims are made for the discovery of ichthyic remains in strata of yet older date. Rohon of Prague has described some fossils as fish-teeth which were found in the glauconite sands of St. Petersburgh assigned in general to the Ordovician (Lower Silurian) era. The writer has not yet seen his paper and can therefore form no opinion upon the evidence. Walcott in 1891 announced the presence of fish fossils in strata of similar age in Colorado. But the evidence from stratigraphy is far from conclusive and the specimens to the paleontologist are strongly suggestive of Upper Devonian affinity and age.

Thus far and no farther at present the placoderms in this peculiar form have been traced down from layer to layer in the stratified crust and from region to region to the place above mentioned. At the same time their structure has become more and more simple and their size smaller until at last we seem to have caught them almost at the moment of origination. But this may not be so, and in strata yet lower we may some day find ancestors more ancestral, placoderms less placodermic, fishes less fish-like than even these strange and almost primeval efforts of Nature's hands and skill.

ON THE VALIDITY OF THE FAMILY BOHEMILLIDÆ, BARRANDE.

By C. E. Beecher, New Haven, Conn.

In the supplementary volume on the trilobites of Bohemia, published in 1872, Barrande carefully figures and describes two imperfect specimens of a trilobite which apparently differs widely from all known genera. For this species he proposes the name *Bohemilla stupenda*, which expresses the importance and remarkable characters it was believed to possess. On account of the impossibility of referring it to any existing group, the family *Bohemillidæ* was constituted for its reception.

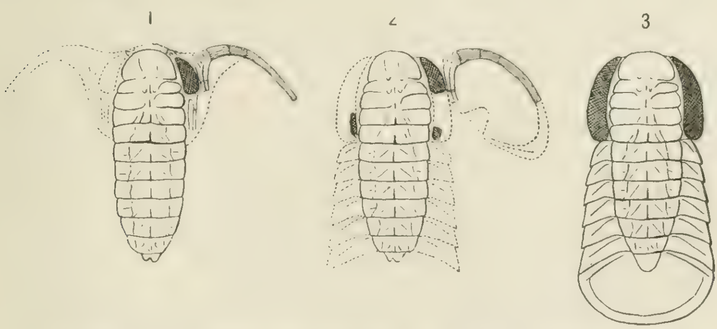
During the past two years, the writer has had occasion to review all the families and genera of trilobites, and the *Bohemillidæ* was the only one which could not be readily interpreted in terms of known trilobite morphology. Barrande's figure of the principal specimen of *B. stupenda** showed a furrow on the curved base of the so-called genal spine which was very suggestive of a pleural groove, and the finely striated spine itself resembled a doublure. Moreover, as there were no defined pleura on the thorax, the specimen seemed to represent only the axis of an ordinary trilobite. The second specimen figured, being simply the glabella, is of no value in this discussion.

Through the courtesy of Prof. Agassiz and Dr. R. T. Jackson, a study was made of the types of this species, now in the Museum of Comparative Zoölogy at Cambridge. This investigation showed that the foregoing surmises were correct, and

*Syst. Sil. du centre de la Bohême, vol. 1, Suppl., pl. 14, figs. 30-32.

that the "genal spine" in question was apparently about one-half of the rim of the displaced pygidium with the doublure, and had no organic connection with the cephalon. Another character shown in the principal specimen and overlooked in the original description was the presence of a fragmentary facetted area at each side of the fifth annulation, or at the base of the cephalon, indicating that originally the visual area extended the entire length of the glabella. The finished margin of the eye, as figured by Barrande, is incorrectly represented as complete, whereas the posterior edge is an irregular and broken line.

This additional information, together with the fact that there are six free axial segments, indicates the proper reference of this species. *Æglina*, Barrande, meets all the requirements in having eyes extending the whole length of the cephalon, six free thoracic segments, and a pygidium with an entire margin and striated doublure. It is important to note that the locality furnishing the specimens of *B. stupenda*, Sancta Benigna, Bohemia, is the chief source, also, of most of the species of *Æglina*. The trilobites from this locality are often compressed and broken, and occur as casts in a soft carbonaceous shale, so that the distinction between fossil and matrix is not always clearly shown.



FIGURES 1, 2, 3. *Æglina stupenda* Barr. sp. (Figure 1, after Barrande.)

Figure 1 of the accompanying cut is after Barrande, with the restored portions represented by dotted lines. Figure 2 is the same, showing the additional facetted areas at the base of the cephalon. The outlines of the eyes, the pleura of the thorax, and the form of the displaced pygidium are supplied.

Figure 3 represents the trilobite restored, on the basis of the interpretation here given.

Bohemilla may, therefore, be recognized as a synonym of *Æglina*, unless the lobation of the glabella and axis should be considered as of generic importance. This would be according a value to this feature greater than is recognized among the other species of *Æglina* which in this respect show equally great variations from the type, *Æ. rediviva*. At any rate the bizarre appearance and remarkable characters ascribed to this trilobite are no longer matters of wonderment, and it is reduced to the rank of an ordinary form.

THE VOLCANIC TUFFS OF SÉGALAS (ARIÈGE). CONCLUSIONS TO BE DRAWN FROM THEIR STUDY ON THE SUBJECT OF THE ORIGIN OF THE OPHITES.

By A. LACROIX, Paris, France.

The existence at Ségalas of ophitic tuffs has recently been announced. Lacvivier has shown that they are older than the calcareous breccia of the lower Lias; Roussel has shown, besides, that they lie upon limestones of the horizon of *Avicula contorta* and that consequently they are contemporary with the close of the Rhetian.

The purpose of this note is to show by the mineralogical study the clearly volcanic nature of these tuffs, and to draw from the results obtained some general conclusions on the origin of the ophites of the Pyrenees.

At Ségalas the tuffs are seen lying between the Liassic breccia and the infra-Liassic limestones raised to verticality. I have collected in these tuffs fragments of quartzite with *Avicula contorta*, which leaves no doubt of their age.

These tuffs present a remarkable analogy with the basaltic tuffs of Auvergne. In the midst of a black mass, composed of little palagonitic fragments cemented by a little calcite, can be seen a considerable number of ejected blocks which reach the size of a man's head; blocks of scoria, of compact lavas, cellular lavas, volcanic bombs with a central nucleus of a fragment of limestone, and numerous pieces of limestone. At certain points these blocks are distinctly stratified, and the tuff has evidently been worked over by water. It is but little coherent, deeply gullied at its outcrops, and in the depressions of the surface the scoria and lava blocks are accumulated. Thus it is possible to witness their remarkable freshness, which recalls that of recent volcanic rocks.

Tuff. Microscopic examination shows that this tuff is formed of little fragments of palagonitic glass, rich in secondary doubly-refracting products, of limestones or calcareous marls and of unaltered pieces of volcanic rocks. They are united by a cement of calcite which is more abundant from the top downward. Thus it passes into the lower Lias limestone.

Projected blocks. (*a*), *Scoria.* The scoriæ are of a reddish brown color. Their cavites are sometimes lined, or filled, with celadonite, calcite, quartz (quartzine) or with chalcedony; often also they are empty and the rock resembles a modern scoria. The microscopic examination shows several microlites of andesine and of magnetite. Sometimes the feldspar is silicified.

(*b*), *Compact lavas.* A frequent kind consists of a reddish-brown lava with a compact texture, enclosing large cavities poor in secondary products; the microscopic examination shows quite numerous microlites of andesine, disseminated in the midst of a brown glass with ferruginous crystallites. Here and there are calcified casts of olivine and of pyroxene. Everywhere are seen the same secondary products as in the scoriæ.

(*c*), *Crystalline lavas.* These lavas are referable to two categories. Those of the first type are white; the microscopic examination reveals in them labradorite microlites embraced in ophitic plates of calcite. Here and there in the midst of these can be seen the débris of augite in process of replacement. The rock contains brownish glass and large octahedra of magnetite; it constituted originally an ophitic labradorite rock. Some specimens belong to a type a little less basic, the triclinic feldspar being andesine.

The second type is more rare and is rich in brown glass. It contains large crystals of augite with a rounded form, associated ophitically with labradorite.

(*d*), *Limestones and volcanic bombs with a limestone nucleus.* The numerous blocks of Triassic or lower Lias limestone do not present any transformation. The thin plates cut so as to show the contacts of the bombs with their limestone nuclei make it apparent that neither the sedimentary, nor yet the volcanic rock, has been modified.

En résumé, the tuffs of Ségalas are composed of volcanic projections of labradorite; the scoriæ are less basic (andesitic) than the lavas. The most crystalline of the ejected lavas present a great analogy of mineralogical composition and structure with the ophites of Rimont, which, contrary to that which happens in the case of the ophites of other regions in the Pyrenees, contain a glassy residue. They are labradorites containing a little olivine and presenting an ophitic structure easily understood in the case of the thin sheets. Thus it seems to me there is little doubt that the ophites (labradorites) of this region represent lava sheets, the points of issue for which were at Ségalas.

I have recently examined many of the ophitic regions of the Pyrenees other than those of Ségalas, and have shown what intense metamorphic phenomena the secondary limestones present at their contacts. I have concluded from this that, as with the lherzolites which they accompany, the ophites are of intrusive origin. This view receives confirmation in the facts observed at Ségalas, which show that the same magma, spread over the surface of the secondary limestones or embracing them in its mass, is incapable of developing in them any of the numerous minerals which form the accompaniments of the ophites properly so-called. These conclusions agree furthermore with my recent memoir on the contact phenomena of volcanic rocks.

There is room, therefore, to consider two categories of ophitic rocks in the Pyrenees, one of an effusive origin, presenting no metamorphic phenomena at their contacts, the other intrusive and developing intense mineralogical changes in the rocks amongst which they are found. There can be no doubt that these two categories of ophites come from a single magma. It remains to find by minute study the differences, however slight they appear at first, which may exist, in a mineralogical point of view, between these two categories of rocks. This question will form the subject of later work.

Paris, 20 Jan., 1896. [*Comptes Rendus des Séances de l'Académie des Sciences.*]

FROZEN STREAMS OF THE IOWA DRIFT BORDER.

By Andrew Gordon Wilson, Hopkinton, Iowa.

The valleys of the streams of Delaware county, and of other counties in Iowa that lie to the north and southeast of it, were considerably deeper in preglacial days than at present. According to Prof. Chamberlin,* the old Mississippi

*Professors Chamberlin and Salisbury, U. S. Geol. Survey, Sixth Annual Report, p. 223. Cf. also data by Frank Leverett, Journal of Geology, Oct.-Nov., 1895.

channel at Dubuque had a depth at least 132 feet below the present low water mark. A number of wells in T. 87 N., R. 3 W., in Delaware county, indicate a depth of channels reaching at least 40 feet, perhaps much more, below the present level of the water in the streams. As this would carry them through the more durable limestone of the Niagara into the soft, easily eroded shales of the Lower Silurian, it is highly probable that their general level was no higher above that of the Mississippi then than now. That is, their channels were 100 feet. more or less, deeper than at present. The relation of the limestone to the shales is the same as that in the Niagara river gorge, although the New York shales are not the equivalent of the Iowa shales in age.

These half-buried channels are generally quite narrow and crowd each other so that there are often several on one square mile. The aspect of this region before the ice invasion must have been decidedly rugged and picturesque. The underlying shales may be held accountable for the depth and narrowness of the channels, and every considerable stream must have been a Niagara river in miniature, with nearly vertical rocky walls rising from 100 to 200 feet above the water, and with falls near the head of the stream, whose hight would depend on the power of the stream.

The meanderings of the bluffs of these streams follow courses in two prevailing directions, east by south, and south by west, and these are noticeably the directions of the systems of joints in the Niagara limestone. While it is not to be supposed that these joints had anything to do with determining the original location and direction of the streams, yet it seems reasonable to suppose that they would fix the angles of the streams, would eliminate projecting points not harmonious with themselves, and would introduce angles in a course that might at first have been straight, but oblique to their directions. This tendency would be greatly strengthened by the presence of the treacherous shales beneath. It will readily appear that a surface with such bold relief, with narrow, deep and angular channels, would offer a high degree of resistance to the movement of the glacial ice.

The South fork of the Maquoketa river lies throughout its entire length from ten to twenty miles inside the border of the drift covered area.* Although thus well within the territory whose surface has been moulded by ice action, the bluffs of the South Maquoketa show at some lower levels the general characters of the Driftless Area. With regard to the lower portion of the Maquoketa river, McGee says:† "In the valleys east of Deep creek, little if any erratic material occurs among the superficial deposits. At the same time the summits and divides are rounded and stretch off to the eastward in gracefully curved dolphin backs, such as everywhere tell of ice action: and the testimony of form is corroborated by that of material, for occasional bowlders peep out from the upper slopes, and patches of gravel are turned up by the plow and exposed in the roadside gullies over the uplands.

"This hybrid configuration is one of the most striking phenomena of northeastern Iowa. It seems anomalous, incongrous, almost incredible, that the hill tops should be moulded into the long and gracefully rounded swells of rock turned out from the ice mill, and that in the same vicinity the older valley bottoms should exhibit the rugose aspect of water sculpture; but the fact is patent to any observer and indeed forms the conspicuous topographic feature of the drift border region."

What is here stated for the regions near the mouth of the stream is true in numerous places of its valley walls as traced through Jones and Delaware counties. Erosion towers, castellated turrets and balanced rocks, which are among the strongest evidences of the absence of ice action in the Driftless Area, are here found in channels that are wholly surrounded by regions showing bowlders, glacial clay and gravel, and all evidences of ice action. Such incongruities are specially striking at the following places:

McCoy's Ford......	Sec. 5,	T. 85 N.,	R. 2 W.
Table Rock	" 36,	" 87 "	" 4 "
Pulpit Rock........	" 25,	" 87 "	" 4 "
Wildcat Rock.... .	" 24,	" 87 "	" 4 "
Steamboat Rock....	" 16,	" 90 "	" 6 "

The last mentioned locality is at the resort known as the Backbone. Indeed, the Backbone itself is an example of this

*See maps of Chamberlin and Salisbury, in the Sixth Annual Report of the U. S. Geol. Survey, plates 24 and 27; also McGee's maps in the Eleventh Annual Report, plates 31, 44, 55, 56, 57.

†U. S. Geol. Survey, Eleventh Annual Report, p. 391.

anomalous topography. It is a narrow tongue of Niagara limestone, about a quarter of a mile long and but a few rods wide, with nearly vertical walls rising about 100 feet above the water of the river, which flows on three sides of it. Its narrow base and numerous deep fissures seem to render it impossible that such a lofty and shattered wall, lying directly across the path of the glacier, at a point fully twelve miles from its nearest margin, could resist the force of the ice action. Yet glacial deposits are found on the summit of the Backbone. That these valleys and erosion forms are the work of the waters since the ice invasion, we cannot for a moment suppose. The explanation, then, of these anomalous and incongruous conditions, is the task undertaken in the present paper. As given beyond, this explanation was suggested by observations made in the spring of 1881 on a small tributary of the Little Turkey river, in the southeast corner of Clayton county, Iowa.

The winter had been unusually long and severe. Snow covered the ground in October and increased at frequent intervals till the middle of the following March, when it lay over three feet in depth in the timber where not drifted. The temperature frequently fell below —30°F. The steep hills that rise to a hight of fully 500 feet on the east and west cut down the daylight in midwinter to little more than six hours in length. This small stream, which flows through the village of Jeffriesville, in a channel cut about five feet below the general level of the road, has its origin at the summit of the Maquoketa shales, at a point in the hills over 100 feet above the level of the village.

This stream froze solid early in the winter. Then, as the warm water from the spring was constantly supplied, it soon sent a stream over its frozen bed. On the next cold night it froze solid again; and thus, by alternate flooding and freezing, re-enforced by the frequent snows, it had by the first of March filled its channel completely, had overspread its banks with a belt of ice several rods in width and fully eight feet deep in places. It rose above the floors of the houses, and the residents made strenuous, and not always successful, efforts to keep the water out of their dwellings, by building walls of snow about the doors and cutting fresh channels for the stream.

Briefly stated, the explanation proposed is this: that these spared monuments of erosion along the Maquoketa river were surrounded by compact masses of ice formed from the waters of the springs and streams native to the region before the Ice age; and that, thus embedded, they were firmly held, while the blade of the huge glacial microtome cut only thin sections from their summits; and that the truncated columns were left undisturbed by the slow melting of the river ice, after the glacial ice had disappeared from above.

The objection may be made that the recent studies of existing glaciers in Alaska and Greenland do not show such frozen streams in advance of the glacial ice. The majority of the glaciers, however, that are now seen in operation, are not advancing but retreating; and this in spite of a heavier snowfall than we can assume for northeastern Iowa in the Glacial period. This is evidently true of the Alaskan icefields, and while the Greenland ice may have again assumed the aggressive, its advance is evidently slow and accompanied by rapid marginal waste; so that the supply of water is spasmodic and largest in the warm season, having volume enough to remove masses that might congeal in their channels during the cold season.

A glacier whose front is stationary, as the result of an equilibrium between forward motion and marginal waste, as well as one that is retreating, as a result of the preponderance of the latter, will manifestly have its front beyond the line of perpetual snow or frost; but it does not appear that this would necessarily be true of an extensive field of ice, where showing a decided advance of front over a comparatively level country. That is, during the early portions of the Kansan and Iowan stages of the Ice age, in northeastern Iowa, the snow line may have been but little behind, or even in advance of, the front of the ice-sheet.

The conditions favoring the formation of such frozen streams would seem to be diminished drainage, constant supply of water at high levels, large snowfall, seclusion from the sun's rays and a sufficiently cold climate. These conditions were present in a marked degree in the region under consideration.

Whatever causes may be assigned for the immunity of the Driftless Area, the absence of ice there was evidently not due to a higher temperature in that area. At the time when the ice front in the Kansan and Iowan stages moved over the channel of the South Maquoketa river, the ice field must have stretched for 100 miles or more in a southwesterly direction from that part of the margin.* The Illinois lobes were at the same time probably nearly as far south as those in Iowa; so that, if we suppose the snow line to have been even forty or fifty miles back of the southern limit of the glacier, it would be as far south as the region in question.

Seclusion from the sun's rays was secured at first by the depth and narrowness of the river channels; and as the ice front in this part may be assumed to have sloped in a northeasterly direction, this itself would aid in excluding the sun's heat in the hottest portion of the day.

This river receives the greater part of its water from springs along its own channel and those of its tributaries. Some of these springs have an altitude equal to, or greater than, that of these relics of water carving. The numerous joints in the Niagara limestone allow free penetration of water to considerable depths; and so the upper limits of the Maquoketa shales must have been an horizon of numerous springs in preglacial days in this border belt, as it is now in the Driftless Area; and the filling of the channels to that level, or higher, would cause the springs to break out at other points still higher. It is worth noting that the erosion towers above mentioned are all in the near vicinity to springs now existing.

The idea of frozen streams is certainly consistent with that of the deep freezing of the soil in the immediate front of the ice-sheet, as affirmed by various writers.†

The question may arise whether the weight and motion of the glacial ice above would not cause a movement in the river ice itself that would amount to glacial action in its effects on the water carved rocks. To this it may be replied that, if the granular structure in glacial ice can be considered to con-

*See plates 55 and 56 in Eleventh Annual Report, U. S. Geol. Survey; also plate 5 in the AMERICAN GEOLOGIST, Aug., 1895.

†See McGee's memoir, Eleventh Annual Report, U. S. Geol. Survey, p. 567; also an article by Prof. Calvin in the AM. GEOLOGIST, Feb. 1896, p. 76.

tribute in any way to its freedom of motion, that factor would be wanting in the ice of these frozen streams. The narrow, deep, rocky channels, with frequent rectangular turns, would also operate against such motion. The river ice would show a surface approximately level, and so give minimum resistance to the glacier's motion over it. And if there is a differential motion in the layers of ice in the glacier, as Chamberlin's studies* seem to indicate, there might easily be motion of a glacier over a land-locked mass of river ice, without the latter participating in the motion.

It would also appear from these same studies,† that in lower latitudes the termination of the ice lobes would be less abrupt than in Greenland, on account of the sun's rays being more nearly vertical; so that any particular portion of the river ice might not be subjected to a heavy load until the region about it would be subjected to the equalizing pressure of the glacier.

The melting of these frozen streams was probably the closing event of the drainage of lake Maquoketa,‡ as the sands that mark the shore of one stage of this lake have about the altitude of the erosion towers in the river bluffs.

This, then, seems to be an explanation of the numerous erosion forms that have escaped the ice action because of their lower altitude, while the exposed summits were smoothed and rounded by the glacial tools. It is not contended, however, that this embedding ice would be preservative of all such forms in the wider and more exposed portions of the river valley, nor in any region where the glacial ice attained a great thickness.

When once a stream is frozen to its bed an overflow must result if the water supply is constant, and this overflow is frozen more easily each time as it spreads in wider and thinner sheets over the congealed mass below. The temperature of the older parts of the ice would perhaps remain considerably below the freezing point, so that at night the liquid layer would be frozen from both its upper and lower surfaces.

---

*See Journal of Geology, Sept.-Oct., 1895, p. 675, et seq.

†See Journal of Geology, July-Aug., 1895, p. 566.

‡See again McGee's memoir, U. S. Geol. Survey, Eleventh Annual Report, plate 61, and page 573.

This explanation would evidently greatly diminish the work demanded of these streams in cleaning their channels of the materials supposed to have been deposited in them by the glacier; and it may also have some bearing on the mode of the formation of the river terraces of this border region of the Driftless Area.

March 31, 1896.

SUBLACUSTRINE TILL.

By Warren Upham, St. Paul, Minn.

Criteria of Deposits of Till in Glacial Lakes.

On nearly level expanses enclosed by the beach ridges of glacial lakes, surfaces of till are more smooth than on the continuation of the same almost level but slightly ascending tracts outside the old lake area. The very remarkable flatness of the sublacustrine till is succeeded, as soon as the highest of the ancient shore lines is crossed, by a moderately undulating contour, with swells and long wave-like ridges of gentle slopes, rising usually 5 to 10 or 15 feet above the intervening hollows. In a broad view of such an undulating till expanse, when it is prairie, as on extensive portions of the borders of the glacial lakes Agassiz and Minnesota, the horizon appears as level as that of the ocean, though near at hand the surface is uneven with massive low ridges of similar width and hight as the heavy undulations into which the sea is raised by great storms. The same till deposit, continuously forming the surface on both sides of the small beach ridge of sand and gravel, is commonly very flat within the lacustrine area, often having no perceptible undulations and stretching many miles as a monotonously uniform plain. From the great extent of this smoothed contour of the sublacustrine till, it appears to be attributable almost entirely to the action of the lake washing the receding margin of the ice-sheet, with only slight later modification by the wave erosion which supplied the scanty beach deposits.

Another feature of the sublacustrine till is an imperfect stratification, usually observable in some degree through the whole or some part of any freshly excavated section, as of cellars and wells, to depths of 10 to 15 feet, or more, below the surface. Instead of the altogether unstratified condition which the till exhibits elsewhere, it has faint traces of bedding in thin and nearly horizontal layers of sand or laminated clay, while yet the chief mass of the deposit consists of intermingled clay, sand, gravel, and boulders, having, with the exception of the obscure bedding, all the characters of typical till.

Both these criteria indicate that the superficial portion of the till was contained in the ice-sheet and was therefore exposed to leveling and partial stratification when its deposition took place in glacial lakes on the border of the retreating ice.

Observations of Sublacustrine Till.

Lake Agassiz. Large tracts on each side of the flat valley plain of the Red river of the North, which was the bed of the glacial lake Agassiz, consist of till, having the very smooth contour and slight stratification here noted. Such deposits of normal sublacustrine till also occupy extensive tracts adjoining lakes Winnipeg and Manitoba and in the vicinity of the city of Winnipeg, where the water of lake Agassiz, shown by the altitude of its east and west shores, was 500 to 600 feet deep when these tracts were first relinquished by the ice-sheet and covered by the glacial lake. The position of the stratified silt and clay of the Red river valley, in a belt along its axial lowest part, shows that these sediments were chiefly fluvial, being supplied by streams flowing northward along this avenue of drainage after the glacial lake and its ice barrier disappeared.

Where the courses of continuation of marginal moraines traverse the area of lake Agassiz, no hills nor even hillocks are found, but the surface has unusually plentiful boulders. The drift corresponding to the moraines is spread so evenly that one scarcely observes any addition above the general sheet of till forming adjacent parts of the lake bed; except that one of these belts of smoothly leveled morainic till, a few miles wide, stretches continuously across the Red river valley, past Ada, Minn., and Caledonia, N. Dak., rising very slightly above the central broad alluvial tract which otherwise is uninterrupted along a distance of 250 miles. If the morainic drift was supplied from the surface of the melting frontal slope of the ice-sheet, it would be washed away and leveled in the lake by the great waves of storms; but if it had been subglacial and thence was pushed out and first uncovered from the retreating ice under the water, much of it would have escaped the lacustrine leveling, and would remain in morainic hills and ridges.

During my exploration of this largest glacial lake of North America, I have recognized no indication of icebergs; and thence it seems to me probable that the receding ice-front had mostly too steep and high an ascent above the water level to permit portions of it to be buoyed up by the lake, which attained a depth of 600 to 700 feet in its deepest north central part.*

Lake Minnesota. The area of the glacial lake in the basin of the Blue Earth and Minnesota rivers, belonging to a date somewhat preceding lake Agassiz, is mainly an exceedingly level expanse of till, with obscure stratification near the surface.†

The Laurentian glacial lakes. Very flat expanses of sublacustrine till are seen in many portions of the areas of the glacial lakes which are now represented by the diminished but still great lakes tributary to the St. Lawrence river. The cities of West Superior, Chicago, and Buffalo, are built mostly on these tracts, and they are very extensive in Canada north of lake Erie and along the St. Lawrence between lake Ontario and Montreal.

The till which was brought by the ice-flow from the lake Superior basin has been mistaken on parts of its areas in Wisconsin for a stratified lacustrine silt. It is characterized by comparative scantiness in the supply of granite, gneiss, crystalline schist and gabbro boulders, by the absence of limestone, and by the large proportion of fine detritus of dull reddish color from the erosion of the Cambrian red sandstones and shales, and of the partly sedimentary and partly igneous Keweenawan series, which form the shores and bed of lake Superior. This red till, with few boulders, has a typical sublacustrine development near Duluth and in West Superior, and forms the flat expanse which gradually rises from the west

*Geol. Survey of Canada, Annual Report, new series, vol. IV, for 1888-89, Part E; U. S. Geol. Survey, Monograph XXV.

†Geology of Minnesota, vol. I, 1884, pp. 441, 460.

end of lake Superior along the Nemadji river and the lower part of the St. Louis river.*

Lake Ohio. The tract called Beech Flats, in Pike county, Ohio, which Prof. G. F. Wright had regarded as a stratified delta of the glacial lake Ohio,† has been recently ascertained by Prof. W. G. Tight to be a smooth tract of till;‡ but, according to the criteria noted in this paper, it may perhaps still be cited as good evidence of that glacial lake held by the dam of the ice-sheet crossing the Ohio valley at Cincinnati.

THICKNESS OF ENGLACIAL AND FINALLY SUPERGLACIAL DRIFT.

From my observation of traces of stratification throughout a long and well exposed section of sublacustrine till at Cleveland, Ohio, the thickness of drift which there was englacial and at last became superglacial, allowing it to be slightly modified by deposition in the water of lake Warren, appears to have been at least 15 to 20 feet.§ Stream erosion near the outermost or Altamont moraine in southwestern Minnesota during the recession of the ice-sheet implies that there, adjacent to especially prominent moraine accumulations, the englacial drift amounted to about 40 feet.‖ Again, from evidence which I think impossible to be otherwise interpreted, the esker of Bird's Hill, seven miles northeast of Winnipeg, Manitoba, seems to prove for that vast plain-like region a total thickness of 40 feet of englacial drift.¶

ALTITUDE OF ENGLACIAL DRIFT TRANSPORTATION.

Although it may not now be regarded, by some glacialists, as consistent with the principles of physics or with the increasing knowledge of the action of existing glaciers and ice-sheets, I cannot doubt the testimony of Bird's Hill, in its relations to the adjacent sublacustrine till sheet and to lake Agassiz, that the englacial drift there, increased above its ordinary amount and perhaps carried to an exceptional hight

*Geol. Survey of Minnesota, Twenty-second Annual Report, for 1893, p. 44, with sections.

†The Ice Age in North America, 1889, pp. 333, 334; with map.

‡Bulletin of the Scientific Laboratories of Denison University, vol. IX, pp. 25-34, with map, Dec., 1895; noticed in the AM. GEOLOGIST, vol. XVII, p. 326, May, 1896.

§Bulletin, Geol. Society of America, vol. VII, pp. 329, 331, March, 1896.

‖Geology of Minnesota, vol. I, pp. 603, 604.

¶Geol. Survey of Canada, Annual Report, new series, vol. IV, pp. 36-42 E.

because of the confluence of ice currents from the northeast and northwest, was borne upward from a low and mainly level country to hights exceeding 500 feet above the land in such volume as to yield above that level the esker gravel and sand of this hill and also its large boulder-like enclosed mass of till. The arguments for high altitude and large amount of englacial drift based on my observations of Bird's Hill seem to me to be strongly re-enforced by the eskers and kames described in Rochester, N. Y., and the contiguous region by Prof. H. L. Fairchild, and earlier in part by Mr. Charles R. Dryer and the present writer.* Inability to understand how the englacial drift was carried up through the lower quarter or third part of the ice-sheet, where, as in Manitoba, it was probably a mile thick, should not forbid the acceptance of conclusions which are well established by definitely observed features of the sublacustrine till and of associated eskers and kames.

NOTICE OF SOME SYENITIC ROCKS FROM CALIFORNIA.†

By H. W. Turner, Washington, D. C.

There is a present tendency among writers on petrography to base the classification of rocks on those characteristics which can be determined from the rock specimen itself. Thus Michel Lévy‡ writes: "One sees, from all that precedes, that it is necessary to base a rational petrographic classification upon contingent facts, independent of geogenetic hypotheses, and that the consideration of the age of rocks, from this point of view, is as hypothetical as that of their conditions of occurrence (*gisement*) in the depths or at the surface. Being given a sample of rock from an unknown province, it is indispensable and it is possible to name and describe it without amphibology. It is possible to determine from it with certainty neither the occurrence (*gisement*) nor its geological age."

---

*C. R. Dryer, Am. Geologist, vol. v, pp. 202-207, with map, April 1890.

W. Upham, Proceedings of the Rochester Academy of Science, vol. ii, pp. 181-200, Jan. 1893.

H. L. Fairchild, Am. Geologist, vol. xvi, pp. 39-51, with map, July, 1895; Journal of Geology, vol. iv, pp. 129-159, with maps and views. Feb.-March, 1896.

†Published by permission of the Director of the U. S. Geol. Survey.

‡Structures et classification des roches éruptives: Paris, 1889, p. 34.

Iddings* states practically the same thing in his monograph on the rocks of Electric peak and Sepulchre mountain, and other prominent authors may be quoted to the same end. It seems to the writer that nothing is more needed to advance petrographic science than the definite use of rock terms, and, if it is necessary to know the conditions under which a rock consolidated and its geological age, it is evident that in many cases we cannot name a rock at all. No mineralogist would consent for a moment to base a classification of minerals on other than contingent facts, and although, since rocks are in most cases mixtures of several minerals, a rock classification must be a classification of mixtures, which vary in each magma from point to point, it is nevertheless true that certain mixtures, of very nearly the same composition and structure, are found in many parts of the world, and admit of being characterized in such a way, that the term applied to them may be made to have a definite meaning. On the other hand, if the fact that rocks are mixtures be not borne in mind the tendency to make rock species may be carried to excess. If the minerals that make up the larger part of most igneous rocks were great in number, a rock classification would require so many terms as to have little practical value, but happily, as all geologists know, this is not the case, and with the enormous advance in late years of our knowledge of the composition of rocks it is perhaps not visionary to hope that a set of terms, which will endure, will soon be agreed upon for the most universal mineral mixtures.

With many of the coarse granular rocks, in which the mineral components are easily recognized, there is already a set of terms in use nearly the world over, but with many rocks occurring as dikes, and with the micro- and cryptocrystalline rocks, there is still much confusion. What appears to be a step in the right direction is the division by Fouqué and Lévy of the plagioclase rocks into an oligoclase-andesine series and a labradorite-anorthite series. The former will contain most andesites and diorites and may be called the diorite family; the latter will contain most basalts, diabases, and gabbros and may be called the gabbro family.

---

*13th Annual Report of the U. S. Geological Survey, p. 663.

In a recent paper by Weed and Pirrson* the following occurs:

It seems to us that the time has come when a sharp distinction must be drawn between the general terms in use by field geologists, such as granite, porphyry, trap, greenstone, etc., and the more exact and definite nomenclature demanded by the needs of petrology. Such terms have a definite and proper value just as tree, bush, and vine have in botany, but the science of petrology demands at present a terminology which will not only be qualitative but quantitative in its meaning. While it is neither possible nor desirable to classify rocks on a strictly chemical basis, it is clearly evident that the lines of mineral and consequently of chemical variation must be more strictly drawn than has heretofore been done. This will find its natural manifestation in a more strict regard to the relative quantities of the various minerals which are present and these quantities within reasonable limits must be expressed.

Professor Brögger † has recently suggested a scheme of grouping of rocks in which the quantitative chemical and mineral composition is taken into account more narrowly than usual. In this way of grouping all rocks of approximately the same mineral and chemical composition are brought together in families without regard to their structure, age, or the mode of their occurrence. Thus the granite family of Brögger will include granite, granite-porphyry, and rhyolite, and the diorite family (medium acid plagioclase rocks) both diorite and andesite. This method of grouping the rocks seems to the writer most desirable, and is essentially followed also by Lévy and Teall and some other petrographers. A rough sketch of such a classification, in so far as it applies to the rocks studied by the writer in the Sierra Nevada, is herewith appended. This is obviously very incomplete, and moreover contains practically nothing original.

The feldspars are the main basis of classification in the feldspathic rocks. The ferromagnesian elements offer a convenient means of distinguishing the rock species.

GRANITE FAMILY,—alkali feldspar and quartz.
- *Granite*,—structure hypidiomorphic or granitic.
  - Biotite-granite.
  - Hornblende-granite.
  - Augite-granite.
- *Granulite*, Lévy (*Aplite*, Rosenbusch),—structure granulitic.
- *Granite-porphyry* (*Microgranite*, Lévy in part).

---

*Am. Jour. Sci., 3, vol. L, 1895, p. 478.

†Die Gesteine der Grorudit-Tinguait-Serie; Christiana, 1894, p. 92. Die Eruptionsfolge der triadischen Eruptivegesteine bei Piedazzo in Sudtyrol, 1895, p. 60.

Quartz-diorite Family,—oligoclase-andesine feldspars and quartz.
Quartz-diorite,—structure hypidiomorphic or granitic.
Quartz-diorite-porphyry,—structure porphyritic.
Dacite,—structure microlitic or glassy.

Syenite Family,—alkali feldspar.
Syenite,—structure granular.
Hornblende-syenite.
Mica-syenite.
Augite-syenite.
Syenite-porphyry,—structure porphyritic.
Trachyte,—structure microlitic, or glassy.

Diorite Family,—oligoclase-andesine feldspars.
Diorite,—structure granular.
Hornblende-diorite.
Mica-diorite.
Augite-diorite.
Diorite-porphyry,—structure porphyritic.
Andesite,—structure microlitic or glassy.

Gabbro Family,—labradorite-anorthite feldspars.
Gabbro,—structure, granular or poikilitic.
Hornblende-gabbro.
Pyroxene-gabbro.
Mica-gabbro.
Diabase,—structure diabase-granular, often ophitic.
Hornblende-diabase.
Pyroxene-diabase.
Basalt,—structure microlitic or glassy.
Olivine-free basalt=labradorite, Lévy.
Olivine-basalt.

Pyroxenite-peridotite Family,—proxene and olivine.

Only one of the rock families noted above, that of the syenites, will be further treated in the present paper.

Syenite Family.

The family of syenites may be designated as that group of igneous rocks composed chiefly of alkali feldspars, that is to say, orthoclase, microcline, anorthoclase and albite. Quartz and soda-lime feldspars are often present in small amount, and there are usually ferromagnesian elements present and these are conveniently used for a further subdivision of the family.

The group may be divided into three general classes according to the structure and degree of crystallization.

Syenites proper—structure granular.
Soda-syenite or albitite—all albite.
Augite-syenite,—alkali feldspar and augite.
Hornblende-syenite,—alkali feldspar and hornblende.
Mica-syenite,—alkali feldspar and mica.

Syenite porphyry,—chiefly dike rocks, with porphyritic crystals in fine holocrystalline ground mass of alkali feldspar, etc.

Trachytes and apo-trachytes,—chiefly surface flows. Structure microlitic and glassy.

The apo-trachytes will include the orthophyres and keratophyres of the paleo-volcanic series of Rosenbusch and Michel

Lévy. The above classification manifestly does not provide for many rock-types of the syenite family, but is sufficient for the purposes of this paper.

Although in the geological literature relating to California syenites and trachytes are often mentioned as occurring in that state, the writer knows of no authentic instance where rocks so called were determined by chemical or micro-optical methods. The trachytes have turned out to be hornblende-andesites and other rocks, and the syenites to be hornblendic granites and diorites.

Augite-syenite.—In a paper in 1895* mention was made of the occurrence of augite-syenite in Plumas county, near Nevada City in Nevada county where an area was discovered by Mr. W. Lindgren,† and as pebbles in Carboniferous conglomerate in Amador county. The augite-syenite of Plumas county (Nos. 165 and 166 Sierra Nevada collection) forms a considerable mass about Hay Press valley in the southeast portion of the area of the Downieville sheet. It grades over into quartz-mica-diorite. These two granitoid rocks form one large area, which appears to be of later age than the Jura-Trias rocks just west (called Milton‡ series provisionally) as there is evidence of contact metamorphism along the border of the Jura-Trias beds.

Hornblende-syenite.—In 1893 Prof. C. D. Walcott brought back from Deep Spring valley in Inyo county a gray, rather coarse-grained granitoid rock, which was given to Mr. J. S. Diller for determination, and by him kindly referred to the writer as being most interested in the region in question. This rock proved to be a hornblende-syenite. A partial analysis (No. 882, S. N.) is given in the table. It is composed of orthoclase, microcline, plagioclase, green hornblende, titanite, apatite and a little quartz.

Soda-syenites.—In a report§ on the Sierra Nevada notice was given of the occurrence of white dikes in the serpentine near Meadow valley, Plumas county. Some of these dikes are composed of coarsely granular albite only (see No. 455 Plumas, in the table of analyses). Such a rock may be called an

*Jour. Geol., vol. III, p. 390.
†See also text of Mr. Lindgren's Nevada City folio, U. S. G. S.
‡See American Geologist, vol. XIII, 1894, p. 232.
§Rocks of the Sierra Nevada 14th Ann. Rep. U. S. G. S., p. 477.

albitite. Other dikes in the immediate neighborhood of the albitite dikes contain quartz in addition to the feldspar, forming a soda-granulite, as the term is used by Michel Lévy, or a soda-aplite, following Rosenbusch. In the serpentine area of Grizzly hill (Bidwell Bar sheet) are numerous dikes of a soda-granulite containing muscovite in addition to the quartz and albite (see No. 725, S. N., table of analyses.)

There are also numerous soda-feldspar dikes northwest of Meadow valley in serpentine by the trail to Rich Bar. Those noted were chiefly finer grained than the dikes above mentioned.

The large serpentine area to the southeast of Meadow valley that contains the soda-feldspar dikes above mentioned is flanked for considerable stretches by areas of a coarsely fibrous dark green hornblende-schist. One of these masses lies on the west flank of Clermont hill. In it are veins of a peculiar blue quartz. (No. 458 Plumas.) Another area is crossed by the south fork of the Feather river to the east of Little Grass valley. In it are dikes of a coarse grained rock (No. 97 S. N.) composed of a very white feldspar, pretty certainly albite, and the same peculiar blue quartz that occurs without any feldspar in the hornblende-schist of Clermont hill, suggesting a genetic connection between the blue quartz veins, and the soda-granulite and soda-syenite dikes just described. The hornblende of the schist is an aluminous variety, containing about 48% of silica.

In another paper* altered porphyry dikes composed chiefly of albite were described as forming the lodes of the Shaw and Orofino mines (the latter now called Big Canyon mine) in Eldorado county (Placerville sheet). In the table of analyses No. 452 S. N. is an analysis of the Shaw mine dike.

The feldspathic nature of the Shaw mine lode was suggested by Mr. C. A. Aaron† in 1892. This article was not referred to by the writer in the paper in the American Journal of Science, as it was not then known to him. A portion of Mr. Aaron's article is here quoted, to give a better idea of the economic value of the lode.

*Am. Jour. Sci., 3, vol. XLVII, 1894, pp. 470-471.
†Eng. and Min. Jour., November 19, 1892.

Whether the main mass of the lode can be correctly called porphyry, can I think, only be determined by microscopic examination; it may be porphyritic quartz having feldspar as a constituent, and what I take to be feldspar also occurs in masses, some of it of a greenish tint. The characteristic material of the lode is a heavy, hard, highly siliceous, dark-gray rock of sub-conchoidal fracture, seamed more or less with white quartz and impregnated with pyrites of which there are two classes, the one hard, bronze-colored, cubical, striated and not very rich in gold, the other softer, brass-yellow and not obviously cubical; this latter kind is rich, and I think there are some tellurets among them. Arsenical pyrites also occur. * * * This is or has been a "poor man's mine," though also affording an opportunity for large operations, and it has been worked in dozens of shallow shafts, and drifts along the sides by "pocket-hunters" many of whom have been richly rewarded for their labor. I learn that fully $200,000 in gold has thus been taken out, in great part by the aid of hand mortars. The feldspar is auriferous where it is permeated by seams of quartz, and the gray rock gives good assays, and also shows coarse gold, even where no quartz is visible.

The Shaw mine lode is shown by Mr. Lindgren on the economic map of the Placerville folio. The specimens, on which the writer's notes are based, were received from Mr. Leo Von Rosenberg, of New York city.

One of the specimens (No. 235 Eldorado County coll.) from the Orofino or Big Canyon mine lode contains, besides the feldspar, much original hornblende; another specimen (No. 234) contains none. This lode is now thoroughly impregnated with carbonates and iron di-sulphide and was said to carry from $3 to $4 per ton in gold.

An examination of the Big Canyon mine was made by Mr. H. W. Fairbanks,* who writes: "An examination of this ore body shows it to be a very hard, compact and fine-grained mass of gray quartz, which is thickly sprinkled with small but regular crystals of iron pyrites. Gold occurs both in the free state and in combination with the sulphurets. The ore carries from 8% to 10% of sulphurets." A twenty-stamp mill and a chlorination plant were being operated at the time of Mr. Fairbanks' visit.

During the season of 1895, in the area of the Sonora sheet, the writer found abundantly white rocks occurring as dikes in various rocks chiefly along the belt of gold quartz mines known as the Mother lode. The similarity of these rocks to

*Twelfth Report of the State Mineralogist of California, pp. 103 and 480.

that of the Shaw mine was at once noted, and chemical and optical analyses made since prove beyond doubt that some of them are essentially the same and may be called soda-syenite porphyries or albitite-porphyries. The same association of these soda feldspar dikes with gold deposits noted with the Eldorado county occurrences obtains with some of the dikes in the Sonora sheet area. Indeed the field and subsequent laboratory investigations make it reasonably probable that some of the quartz veins along the Mother lode have been formed by replacement of the feldspar of these dikes with silica. This is best seen in the neighborhood of the Tuolumne river, where these dikes accompany the lode at most points and are often filled with secondary quartz veinlets, dolomite and specks of iron-di-sulphide. This is finely shown at the north end of the croppings of the Bachelor quartz vein on the north bank of the Tuolumne river, two miles southeast of Jacksonville. The vein lies at the contact of a body of serpentine on the west and a body of clay slate or schist, probably of Carboniferous age, to the east. The slates dip N. 30° E., at an angle of about 65°. The vein itself is composed of white quartz, dolomite and mariposite, a micaceous mineral often of a bright green color. Just east of the vein, in the clay schists within a width of 30 feet, are six or eight dikes, which usually run parallel with the strike of the schists, but at two points cut across the schistosity. Such a series of dikes might be called a multiple dike, following Lawson,* as it is reasonably certain that at some depth below the surface they all come together. The dikes vary from two inches to two feet in width. Quartz veinlets, one with a convoluted course, cut both the schists and the dikes. Between the dikes and the ledge is a broken up mass of the dike rock of a reddish-brown color, penetrated by quartz veinlets and seams of dolomite and apparently in a fair way to form a quartz vein, like that immediately west, if the alteration should go farther. This mass seemed a friction breccia and would indicate movement and faulting along the vein. A microscopic examination of this breccia showed it to be made up of fragments of the dike rock cemented by dolomite and quartz. Throughout the rock, as well as in the dikes just east, is scat-

*American Geologist, vol. XIII, p. 293.

tered iron sulphurets (FeS_2) in minute specks. The brown color is due to abundantly disseminated limonite. The microscope shows the dike rocks, where not replaced by silica and dolomite, to be composed almost entirely of interlocking grains of feldspar with some larger twinned feldspars, in fact identical as to composition with other similar dikes, which may be seen along the Mother lode one mile to the northwest or about one mile due east of Jacksonville, and to the east of Moccasin creek on the south side of the river. Although the dike to the east of Moccasin creek contains at several points numerous quartz veinlets, at no point was there as good evidence obtained of the formation of quartz veins of some size by replacement of the feldspar of the dikes with quartz and dolomite, as at the place just described, on the north bank of the Tuolumne river.

In the bed of Moccasin creek, at its mouth, is a large cropping of white granitoid rock. This is the north end of the Moccasin creek dike, which extends thence nearly or quite continuously southeasterly for about two and a half miles. It crosses the road to Groveland, about one-third of a mile east of the bridge over Moccasin creek. Except at the north end, it lies entirely to the east of the creek, gradually increasing in altitude and in distance from the creek to the southeast. This dike was first noted by the writer in 1886, but no investigation was made as to its nature. It is mentioned by H. W. Fairbanks in a paper on the Mother lode,* but was called by him a granite dike, which rock indeed it resembles to the naked eye, and as noted above the north end of the dike is a soda-granite as the term is used by Rosenbusch, or soda-granulite, according to Michel Lévy. Specimens of this dike were collected at a number of points. The granitoid portion at the north end contains a good deal of quartz, and may be called a soda-granulite It is composed of quartz, muscovite and albite or soda-feldspar. Analysis of this soda-granulite is given in the table (No. 1523 S. N). By far the larger part of the dike, however, is made up of albite feldspar only, and is mostly finer grained than the granitoid rock of the north end. It may be designated a soda-syenite (albitite) porphyry. Thin sections from different portions of the dike show a

*10th Ann. Rep. State Min. California, p. 45.

somewhat different structure and composition, but the variation is small. The porphyry is made up chiefly of interlocking grains and prisms of albite, often untwinned, and in some sections there are definite phenocrysts of polysynthetically twinned feldspar (probably likewise albite) developed. Rather abundant in some specimens is an olive-green mineral, in grains and prisms. The extinction is sensibly parallel to the prism, and the interference colors are bright. Good cross sections showing beyond doubt the nature of the cleavage were not found, but so far as could be made out the cleavage is similar to that of ægirite, and it is thought to be that mineral. These dikes, therefore, show some analogy to certain dikes in Norway, described by Brögger, and called by him sölvsbergite. The variety found near Lougenthal* is composed chiefly of albite, but contains also microcline, hornblende (katoforite and some arfvedsonite), ægirite, traces of biotite, and quartz, accessory apatite, and zirkon, and occasional minute grains of a perovskite-like mineral.

Dikes of syenite-porphyry were also noted in some siliceous schists or thin bedded quartzite of presumably Paleozoic age to the north of the Merced river. One of these dikes about 9 miles southeast of Coulterville in a much decomposed condition, can be traced for a mile or more with a strike to the west of north. The soft, decomposed dike material has apparently been auriferous as numerous cuts have been made in it, and claims located. As this particular dike was not investigated chemically or optically it is quite possible that it contains some free quartz, and is more nearly related to No. 1639, than to the soda-syenite porphyry of Moccasin creek.

In the canyon of the Merced, on the steep slope west of the river just down stream from the mouth of the north fork, are from fifteen to twenty white dikes from six inches to six feet in width. These dikes are nearly vertical following the dip of the schists (75° E.) but at other points cutting them at a slight angle. This group of dikes may also be called a multiple dike. A section from a similar dike probably a continuation of one branch of the multiple dike, taken just opposite on the east side of the river (No. 1639), shows a few twinned

*W. C. Brögger: Die Gesteine der Grorudit-Tinguait-Serie, Christiana. 1894, p. 76.

needles of a pale brown hornblende, and numerous idiomorphic phenocrysts of plagioclase in a microcrystalline granular ground mass of feldspar, muscovite and probably quartz, for the silica contents (71.88%) is too high for all the silica to be in the constituents already mentioned. In the table of albite analyses given in Dana's Manual of Mineralogy, 69% is the highest amount given, and it is therefore evident that if no more basic element than albite were present, the silica percentage could scarcely reach the amount found by Mr. Steiger in the rock. Nevertheless no quartz was certainly microscopically determined in the rock. The feldspar phenocrysts are many of them twinned on the albite law giving symmetrical extinctions on the trace of the twinning plane (010) of from 6.5° to 21°, the average of nine crystals determined being 13°; none were detected showing albite and carlsbad twinning combined, so that the new method of Michel Lévy* for determining feldspars could not be applied. From the lime percentage of the rock (2.03%) and from the general tendency of the more basic feldspars to crystallize first, and the apparent formation of epidote directly from the feldspar phenocrysts it is presumed that they are near andesine in composition. The rock may be provisionally called a soda-granite porphyry.

Along the borders of the serpentine area from six to seven miles southeast of Coulterville are several soda-syenite dikes. Some of them follow quite closely the contact of the serpentine and the adjoining rock, which, to the east of the serpentine, is a greenstone (apo-augite-andesite) tuff and to the south is the same belt of siliceous Paleozoic schist or quartzite before noted. One of these dikes apparently forms the lode of a gold deposit (No. 1555) as it had evidently been mined. It is much altered in places, containing abundant quartz, calcite or dolomite, and sulphurets.

There were some dikes in the greenstone itself. One of these shows the same pale hornblende needles found in No. 1639 and in a fresher condition.

Between the serpentine body above noted and the area of siliceous Paleozoic rocks is a white dike fifty feet in width at one point, where it is crossed by the road from Buckhorn

*Étude sur la détermination des feldspaths, 1894, p. 33.

mountain to the north bank of the Merced river, opposite the old Benton mill. This dike in following the contact makes an S-shaped curve. Some of the syenite-porphyry dikes are also to be seen near the vein of the Red Bank gold quartz mine on the north side of the Merced river, about half way between Benton mill and Split Rock ferry.

The rock described by Dr. Charles Palache* as containing a blue soda-hornblende, called by him crossite. appears to be very similar in mineral and chemical composition to some of the dikes described above. Dr. Palache's material came from a boulder in the Coast ranges near Berkeley, but was presumed to be of local origin. It is probably from a dike in the neighborhood. At a future time a more exact description of the soda-syenite dikes of the Sierra Nevada will probably be published.

Apo-trachytes.—The fossiliferous beds of Plumas county, called Robinson formation by Mr. Diller, are largely made up of tuffs, in which porphyritic feldspars are abundant. These beds are considered by Prof. Walcott and Mr. Schuchert as of Upper Carboniferous age. Chemical analyses (Nos. 219 and 352) appear to show these tuffs to have the composition of trachytes and this is confirmed by a microscopical examination, for while the feldspathic material of the ground mass is difficult of determination, on account of the minute size of the grains and the presence of much secondary mica, the porphyritic feldspars are seen to be microcline and orthoclase.

Trachytes.—In the area of the Big Trees sheet, in 1887, the writer collected some peculiar looking Tertiary igneous rocks on the ridge north of Beaver creek, about one mile northwest of the South grove of Big trees. The lower part of the igneous mass (No. 86 Tuol. Co.) is a dark, fine-grained, basaltic looking rock. The microscope shows the phenocrysts of plagioclase to be near labradorite. There is also augite present. The feldspars of the glassy microlitic ground mass are much more acid than the phenocrysts. Overlying this dark, very fine-grained lava is a somewhat coarser dark-brown glassy fragmental-looking lava containing black mica (No. 85 Tuol. Co.). The microscope shows this to be a tuff containing bio-

*Bull. Dept. Geol. Univ. of Calif., vol. I, p. 182.

Analyses of rocks of the Syenite family.—Alkali feldspar.

	Horn-blende Syenite	Augite-syenites		Soda-syenite (Albitite.)	Soda-syenite (albitite) Porphyries.			Soda-granite Porphyry.	Soda granulites or aplites.		Orthophyre (apo-trachyte) tuffs.		Trachytes.		
SPECIMEN NUMBER.	882 S. N.	165 S. N.	20 Amador.	455 Plumas.	452 S. N.	1521 S. N.	1522 S. N.	1639 S. N.	1523 S. N.	725 S. N.	219 Plumas.	352 Plumas.	85 Tuol.	86 Tuol.	1420 S. N.
SiO_2	59.48	55.04	55.45	66.54		67.53	66.81	71.88	69.66	76.00	53.98	55.29	61.09	59.88	62.33
TiO_2						.07		.17		.04					1.05
Al_2O_3					about 20.00	18.57		15.57		14.88					17.35
SO_3						trace				trace					
Fe_2O_3						1.13		1.07		.65					2.98
FeO						.08		.30		.10					1.63
MnO						trace		none		trace					.08
Cl										trace					
F						trace				trace					
CaO	5.94			.43	.49	55	1.03	2.03	1.45	.19	2.78	3.08	4.94	5.09	3.23
SrO						trace		.08							.05
BaO						none		.02		trace					.24
MgO		3.41	4.11			24		68		.06					1.05
K_2O	5.75	1.41	5.18	.77	1.15	.10	.07	1.80	2.85	2.77	1.88	5.58	5.27	5.06	4.46
Na_2O	4.62	4.27	1.73	.89	8.72	11.50	11.18	5.81	4.49	3.52	5.03	4.65	3.69	3.90	4.21
Li_2O				10.28		none		none		none					
H_2O below 110° C.						.15		.11		.20					.44
H_2O above 110° C.						.31		.68		1.42					.75
P_2O_5						.11		.08		.11					.29
CO_2								none		none					
C															11
FeS_2															.08
Total						100.34		100.28		99.94					100.33

tite and feldspar phenocrysts and microlitic fragments in a brown, glassy ground mass; one large grain of iron oxide was noted. The partial chemical analyses of these rocks indicate that they both may be trachytes. Rocks exactly similar to these were collected by Mr. F. L. Ransome and the writer in the ridge south of Highland creek near the east border of the Big Trees sheet and to the west of the Dardanelles. At one point at least they overlie andesite tuffs, but at other points appear to be covered by andesite tuffs, so that it would appear that there were trachytic eruptions during the andesitic period.

This preliminary notice of the above syenitic rocks seems warranted on account of the economic interest attaching to some of the occurrences and also on account of the unusual nature of some and the rarity of all of them in the Sierra Nevada.

The analyses of Nos. 30 Amador, 165, 725, 1521, 1522 and 1523 Sierra Nevada collection were made by Dr. H. N. Stokes of the U. S. Geological Survey; Nos. 219 Plumas, 352 Plumas and 452 and 1639 Sierra Nevada collection by Mr. George Steiger; and No. 455 by Dr. Hillebrand; Nos. 85, 86 Tuolumne county and 882 Sierra Nevada by Dr. Peter Fireman, of the Columbian University of Washington.

The analyses of the soda-granites and of the soda-granite-porphyry are included in the table of analyses of syenites as a matter of convenience, although obviously they are not syenites.

Analysis 1420 S. N. is of a trachyte or a trachyte tuff from the Big Trees district, from an area three and three-fourths miles southwest of Clover Valley, Tuolumne county. Included in this fragmental-looking lava there are sometimes minute glassy black particles resembling lignite, and these are presumably responsible for the carbon shown in the analysis, which is by Dr. Hillebrand. No. 1420 is very similar to No. 85, and like it contains biotite, which is wanting in the supposed massive trachyte No. 86.

EDITORIAL COMMENT.

The Ozarkian Epoch.

A very timely suggestion is made by Mr. Oscar H. Hershey in *Science* for April 24, 1896 (new series, vol. III, pp. 620-622), in proposing that the time of great epeirogenic uplift succeeding the deposition of the Lafayette formation and causing extensive erosion of the Lafayette and underlying beds shall be named the Ozarkian epoch. This designation comes from Mr. Hershey's studies of the stream sculpture of the Ozark plateau, as published in the American Geologist for last December (vol. XVI, pp. 338-357). This long and most remarkable epoch, when the Layfayette uplift of the North American continent and of Europe culminated, inaugurating the Ice age, had been recognized and definitely noted, as one of the Quaternary series of epochs, in the American Geologist for May, 1895 (vol. XV, p. 294). The quietude of the Tertiary era in eastern North America was followed by a strong contrast in the epeirogenic movements of the Lafayette, Glacial, and Recent periods. It seems therefore preferable, as in the article last cited, to include under the Quaternary era the entire Lafayette period, in both its epoch of deposition of the Lafayette formation (thought by the present writer to be not marine, but fluvial, as the first result and record of the uplift at its beginning) and the closely subsequent Ozarkian epoch of great elevation and erosion. The extraordinary physical changes of the Lafayette, Ozarkian, Glacial, and Champlain epochs, together constitute a series so widely different from the much longer preceding repose of Tertiary times that they seem to be naturally united in the Quaternary era, which also reaches on to the present day, unless the Recent period, while man's growing supremacy has modified the earth's surface by his cultivated fields, villages, and cities, shall be named, as by Le Conte, the Psychozoic era. W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Saint Peter Sandstone. By F. W. SARDESON. (Bulletin of the Minnesota Academy of Natural Sciences, vol. IV, no. 1, pp. 64-88, plates 2-4, 1896.) In this paper Dr. Sardeson discusses briefly (rather too briefly we believe) the thickness, geographical and geological distribution, structure, lithologic and paleontologic characters, physical relations, stratigraphic position, correlation and origin of the Saint Peter sandstone. While not much new light is thrown upon the vexed problems connected with this remarkable formation, the paper is nevertheless of value because it affords a convenient arrangement of the more important facts concerning the subject that have accumulated during the past fifty years. In discussing the origin of the Saint Peter Dr. Sardeson suggests a theory to explain the purity of the sandstone that seems to be as plausible at least as the chemical theory. "The purity of the Saint Peter sandstone, the paucity of its fossils and its variable depth are all due to the effect of percolating waters and were not original characters, and, further, that the supposed unconformability at its base may have been produced solely in this manner. That is, that the Saint Peter has simply had all soluble material washed out of it, that it is thus reduced in thickness, and that the now dolomitic formations immediately beneath have been attacked in a similar manner and reduced, the whole process causing a shifting of the sand sufficient to produce inequalites in its thickness."

In our opinion the greatest value of the paper lies in its paleontological part. Heretofore the known fauna of the Saint Peter was extremely limited, but, mainly through the efforts of Dr. Sardeson, we know of at least twenty-eight species, of which nineteen are described as new, one was described some years ago by Prof. N. H. Winchell, five are referred more or less doubtfully to well-known Trenton species, and three are too ill preserved to be determined satisfactorily. Excepting five species (three Brachiopoda and one each of Bryozoa and Spongia) the fauna is entirely molluscan (Lamellibranchiata thirteen, Gastropoda seven, Cephalopoda three) and in this respect compares very well with the fauna of the underlying Shakopee dolomite. But the individual species are widely different, while they agree much better with Trenton types.

Considering the general imperfection of Saint Peter fossils, a critical review of Dr. Sardeson's classification of his new species may not be quite fair. Still, it seems to us, he might in several instances have reached without much trouble more satisfactory results. Thus his *Modiolopsis affinis*, *M. gregalis* and *M. senecta* cannot possibly belong to *Modiolopsis*, while his *M. litoralis* should have been referred to *Orthodesma*. What led him to place his species *absimilis* under *Tellinomya* we cannot imagine. In the shape of the shell and style of its surface marking it is totally different from all of the numerous

Paleozoic types of that genus and family. Had he called it a *Modiolopsis* and placed it near *M. pholadiformis* Hall, all must have been satisfied until the discovery of its internal parts shall have given us more reliable evidence of its true position in nature. Again we do not see why his species *fucoida* should be referred, even doubtfully, to *Rauffella*, nor where he gets his information that *R. filosa* Ulrich, is, like his species, "branched at regular intervals." The writer has seen over a hundred specimens of *R. filosa* and not one showing any evidence of branching. Finally, it is to be observed, that the illustrations are of an inferior order, while the paper contains more typographical errors than are usually found in scientific publications although perhaps the author is not responsible for these defects. E. O. U.

Missouri Geological Survey, Sheet Report No. 4. Report on Mine la Motte sheet. By CHARLES ROLLIN KEYES. (132 pp., 14 pls., map, Jefferson City, 1895.) In this report Dr. Keyes deals with an area of exceptional interest in that it includes at once many of the more important localities for the study of the Ozark uplift, and one of the oldest and best known mining regions of North America. It was at the Mine la Motte that the early French explorers in 1720 found the lead deposits said to have been even previously known to the Chickasaw Indians. Since that date mining has been continuously carried on, and among the ores taken out may be mentioned lead, iron, copper, manganese, nickel, cobalt and silver. More recently a large quarry industry has grown up, and granite, porphyry, limestone, marble and sandstone are all quarried. The rocks exposed within the area covered by the sheet include (1) the Knob Lick granite, (2) Iron Mountain porphyry, (3) La Motte sandstone, (4) Fredericktown limestone, (5) Le Sueur limestone. The granite and the porphyry are referred to the pre-Cambrian and are quite fully described by Keyes and Haworth jointly. The sedimentary beds are separated from the crystallines by a marked unconformity and are considered to belong to the Cambrian. The areas covered by the different formations are shown upon one of the excellent maps being issued by the Missouri survey, the geology being by Keyes and Haworth and the topography by Lonsdale and Theilman.

The crystallines occupy the central and southwestern portion of the area, the clastics being laid down against them. The sedimentary beds have an important dip away from the crystallines along the contact, but become horizontal within a limited distance to the northeast. Folds are unimportant and faults, with the exception of that at Mine la Motte, are of small throw. Fumarole action is shown only at the silver mines where quartz veins are also found. Dykes of basic material fill in joint crevices in the crystallines, but are earlier than the clastics. The granite and porphyry are eruptive and belong to a single magma. The area is a region of super-imposed streamways. The crystalline hills of the southwest are semi-alpine in character and rise to a dissected peneplain referred to the Tertiary. The chert hills of the northeast rise to the same plain. Between these two lies the broad Farmington lowland.

which is post-Tertiary and in age immediately precedes the present period of stream cutting.

It is of interest to examine this area, as forming a portion of the Ozark uplift, in connection with Russell's recently published notes upon "The Nature of Igneous Intrusions.* The similarity existing between the structure of the Black hills and the Ozarks is striking. In each the central core is a mass of granite surrounded by sedimentaries which dip steeply away from the crystalline core, but within a short distance become horizontal. Russell would regard the Black hills as due to an intrusion of molten rock which took place below the surface and which on account of the weight to be lifted and the viscosity of the mass did not expand into a sheet, but produced local elevation. The exposure of the core of the hills is due to a period of later erosion.

That the original shape of the Ozark uplift was such a dome has been inferred by Winslow and others, and that the amount of erosion since has been very great may be inferred from the remnants of Coal Measure strata and the superimposed streams, as well as the great differences in elevation between the Tertiary peneplain and the Farmington lowland described by Keyes. The character of the igneous rocks is also similar to that of those found in the Black hills and the legitimate inference would seem to be that in origin the two uplifts were similar. There must, however, have been in the Ozark region considerable differences in elevation before the sedimentary beds were deposited, as is shown by the marked unconformity between the two and the presence of a basal conglomerate. Indeed Keyes says: "The marked inclination of strata which has often been ascribed to low folds is the result of peculiarities in the original deposition of the beds, and not of deformation after sedimentation had ceased. Very noticeable dips are apparent where the stratified rocks rest upon the ancient crystalline hills,"—p. 57. The presence of a similar unconformity below the "Potsdam" of the Black hills, as noted by Newton, would seem to indicate similar conditions and would apparently lend support to the belief that in each case the uplift is due to the intrusion of a laccolitic mass below the granite.

H. F. B.

Minéralogie de la France et de ses Colonies: Description physique et chimique des minéraux, étude des conditions geologique de leurs gisements. Tome premier. Par A. Lacroix. (Baudry et Cie, 1893-1895, Paris.) This volume has been published in two fascicules, the first having appeared in January, 1893. The appearance of the second fascicule, completing volume 1 of the work, occurred in December, 1895. This volume contains 719 royal octavo pages and has numerous figures throughout illustrative of the crystallographic and optical characters of the minerals discussed. The classification adopted is that of Groth, but modified by the introduction of the basic silicates and the titanates in the first part of this volume. The second volume, now in press, will be devoted to the feldspars, carbonates, sulphides, etc.

---

*Jour. Geol., IV, 2, pp. 175-194, 1896.

The name of each species is followed by the chemical formula according to the most recent research. After the expression of the crystalline system, which is followed by the dimensions of the primitive form, the author has added the values of the parameters referred to the usual axes, the forms observed from localities mentioned in the work, angles measured and calculated, peculiarities of elongation or flattening, twinning, striation, hemihedry and mechanical deformations. Under cleavage he has included also gliding-planes with the designation "planes of separation," which he considers, nevertheless, of secondary origin. Hardness, specific gravity, color, inclusions, pleochroism, chemical composition, blowpipe characters, alteration and its products are followed by a statement of the distinguishing characteristics of each species. In giving the geographical distribution of the various species in France the author follows a classification by means of which the geological relations and sometimes the origin of the species are expressed.

It is, however, in the matter of the optic properties of minerals that the work shows at once its unique character and its greatest excellence. An expert microscopist could hardly produce a work of this kind without placing great stress on this branch of mineralogy, and this quality of the volume will render it a favorite with petrographers. The excellent methods of the French petrographers find in this work their constant application and test. It is a companion and supplement of "Minéraux des Roches," by Michel-Lévy and Lacroix. The author takes special pains to express the optic characters of microscopic crystals. In general, the optic properties are expressed by the use of little rectangular diagrams which indicate the position of the plane of the optic axes, the size of the angle 2V, and frequently the apparent angle 2E about the acute bisectrix.

The work is characterized, besides, by the publication for the first time of a great number of new observations, largely microscopic, on the properties of minerals. It marks, therefore, an important epoch in the progressive mineralogy of France, and constitutes a valuable contribution to the science at large. Associated as the author is, intimately, with the leading mineralogists and petrographers of France, Des Cloiseaux, Michel-Lévy, and Fonqué, he has had access not only to their material, but to all the collections in the various museums, public and private, of Paris, and of the provinces. While it is, therefore, in name, a description of the minerals of France, it amounts to a full treatment of nearly all minerals. N. H. W.

Preliminary Lists of the Organic Remains Occurring in the various Geological Formations comprised in the South-west Quarter-sheet Map of the Eastern Townships of the Province of Quebec. By H. M. Ami. (Ann. Rept. Geol. Survey of Canada, new ser., vol. 7, pp. 113J-157J, 1896.) This is an appendix to Dr. Ells' report on the geology and resources of the S. W. quarter-sheet map of the eastern townships of Quebec. It contains a mass of evidence upon which the geological boundaries of the various sedimentary, and for the most part highly fossiliferous, formations were delineated. The following formations are included in the appendix: Potsdam sandstone, Calciferous formation, Chazy formation, Phillipsburg series (=Fort Cassin rocks), Quebec City formation (in which are included the Farnham limestones), the Trenton (including the Black River), the Utica, Lorraine, besides Silurian and Devonian areas.

In the Devonian two horizons are noted and characterized by different fossil remains, viz: a horizon with abundant corals, probably Upper Helderberg or Corniferous in age, and a horizon characterized by the presence of *Spirophyton*. Since the publication of the report the form occurring on Sargent's bay has been shown to be more akin to *S. velum* than to *S. caudagalli*, and the rocks from which this was derived are probably a little newer than they were at first designated. The Silurian outlier on St. Helen's island, near Montreal, has received some degree of attention and a revision of the good work done by Sir Wm. Dawson, Prof. Donald and Dr. W. E. Deeks is therein incorporated.

This paper contains interesting notes on upwards of 84 collections, made chiefly by Dr. Ells and his assistants, for the preparation of his report (now in press), also on collections made by various officers of the Survey at the various dates indicated. The lists of fossils are classified zoölogically and chronologically and will serve as important data in the determination of the various geological formations and horizons comprised in the Montreal sheet of the Eastern townships of Quebec, about which there has been so much controversy at different times.

Mineral Resources of New York State. By F. J. H. Merrill. (Bulletin of the New York State Museum, vol. II, no. 15, 8vo, 233 pp., 2 maps. Albany, 1895. Price 40 cents.) This bulletin is one of the valuable series issued by the New York State Museum at irregular intervals since 1887. The subject matter has usually been of special interest to the citizens of New York and has followed the lines of practical entomology, botany, and practical geology, thus, in a way, supplementing the work of the geological survey. The material for this bulletin was largely gathered in preparing for the New York exhibit at the World's Columbian Exposition held in Chicago in 1893.

The author gives in a concise form descriptions of those industries of the state which are based on its mineral wealth, such as stone quarrying, iron mining, clay and pottery working, mineral paint manufacture, salt production, and the preparation and sale of fertilizers, abrasives, mineral fuels and mineral waters. Lists of the companies engaged in winning and preparing the various products for market, and of the localities in which the materials are found, are given, and the diverse industries are briefly described. The geological relations and in many cases the chemical and mineralogical composition are given.

Being accompanied by two geological maps showing the locations of the various mineral deposits of value and furnished with an excellent index, the bulletin is a complete hand-book and guide to the extensive natural industries of the empire state.

It is in the preparation and publication of just such practical and non-technical treatises as this that the scientist and geologist contribute most directly to the dissemination of information among those not technically educated and thereby promote the material welfare of the community. In subject matter, in arrangement and in appearance this bulletin sets a high standard for others, and although it may not be excelled, it should serve as an incentive to economic geologists of other states to do as much for their own regions. H. V. W.

Annual Report of the Minister of Mines (of British Columbia) for the year ending 31st December, 1895. By JAMES BAKER. (Roy. 8vo, 82 pp., 1 table and 7 sketch maps. Victoria, 1896.) This report, which is the 22d annual, gives a very complete summary of mining operations in British Columbia for 1895. The gold and silver production during the year is said to have been $636,544, of which the silver amounted to $255,200. A small amount of platinum is reported, with a value of $3,800. The production of coal from the three active collieries of the Province was 939,654 tons, of which the domestic consumption amounted to 188,349 tons, and the remainder was shipped to United States ports, principally Californian.

Considerable information is given concerning the recent development of placer mining and river dredging for gold. At one locality the improvements already made include the construction of 14 miles of ditches, and the laying of 15,097 feet of steel hydraulic piping, ranging in size from 18 inches to 24 inches in diameter, and having a thickness of 9-32 of an inch, calculated to hold water under a head of 998 feet.

Among the difficulties encountered in dredging for gold in the Fraser river is the sudden rise of water in the spring when the river frequently rises 50 feet or more without previous warning. Much of the gravel is said to be worked by shafts and underground tunnels, or in situations where it is necessary to elevate the tailings 100 feet or more by hydraulic elevators in order to dispose of them. Even under these disadvantages it is said to be possible to realize a profit if the operations are conducted on a large scale. H. V. W.

New Ordovician Genera and Species of Trilobites. By J. BERGERON. (Bull. Geol. Soc. of France, 3d ser., vol. 23, p. 465, 1895.) In this paper Dr. Bergeron describes a number of forms whose exact position in the Ordovician system is not determined. He gives a fuller description of the new subgenus *Calymenopsis* established by him in association with M. Munier-Chalmas. In the description of the two species, *Dicellocephalus (?) villebruni* (new) and *Asaphelina barroisi* (p. 32), he remarks on the resemblence of these forms to the true *Dicellocephali* found in the uppermost Cambrian beds of America, Great Britain and Sweden. New species of *Ogygia* and *Æglina* are described, but the most notable type described is his new genus *Dictyocephalites*, which, with some features that recall *Cheirurus*, is referred to the neighborhood of *Eurycare*. The head-shield is very broad, and the genal spines go out from the middle of the cheek-margin as in *Eurycare*. The thorax is of numerous joints, and the pleural spines stand out directly from the body. The pleural groove has an unusual course along the front, but nevertheless terminates behind the spine. The genus takes its name from the reticulate ornamentation of the cheeks. A concluding note relates to the Carboniferous form *Prestwichia crepini* of M. Boulay. G. F. M.

Beitrag zur Kenntniss der Trilobiten-fauna im mährischen Devon bei Celechovitz. By F. SMYCKA. (Acad. des Sciences de l'empereur Francois Joseph I: Bull. Internat.; Class. des sci. math. et nat., pp. 1-9, pl. 1, 1895.) The author has brought together a considerable list of species from the Devonian limestones near Celechovitz in Moravia. These are of much interest as the rocks have been but little studied. "There has been no systematic investigation which would give us either a knowledge of the different strata and their parallel with the formations of other countries, nor a conception of their organic life." Following a list of about 60 species, which serve to indicate Upper Devonian age of the fauna, are descriptions of several trilobites, two of which, *Proetus celechovicensis* and *P. moravicus*, are new. J. M. C.

Ueber angebliche Organismenreste aus präcambrischen Schichten der Bretagne. By HERMANN RAUFF. (Neues Jahrb. für Mineral., 1896, Bd. 1. pp. 117-138.) Barrois' announcement in 1892 of the discovery of organisms in the Archean rocks of Brittany, followed by the more elaborate memoirs of Cayeux in 1894-5, aroused the liveliest interest of paleontologists. These fossils have been described as radiolarians and spicules of sponges. Doubt is now cast over all these determinations by Rauff. After an examination of the original preparations showing the sponge spicules, the author pronounces them of inorganic origin, probably minute aggregates of pyrite. Arguments are also adduced to show that the supposed radiolarians are also of similar nature. J. M. C.

Some Notes on the Occurrence of Uranite in Colorado. By RICHARD PEARCE. (Read before the Colorado Sci. Soc., Sept. 9, 1895; 3 pp.) The author states what is known of the occurrence of this rare and interesting mineral in the Wood lode, Leavenworth gulch. Gilpin county, about one and one half miles from Central City (not at Black Hawk, as stated in Dana's System of Mineralogy). Mr. Pearce first found the mineral at the above locality in 1871, and soon after a considerable quantity of the uranite was extracted and sold in London. In 1894 the mine was again opened and another deposit of this mineral was found. Dr. W. H. Hillebrand pointed out that nitrogen was present in uranite, but recently Prof. Ramsey has discovered that the bulk of the gas regarded as nitrogen is the new element helium. U. S. G.

CORRESPONDENCE.

The Algonquin and Nipissing Beaches. In your editorial comments on my letter of February 15 last, published in the American Geologist for April, I am somewhat surprised to find another repetition of an error which is more than palpable and which has been several times corrected in the clearest terms. Towards the close Mr. Upham uses these words, " * * there ensued lake Algonquin, represented by the Algonquin or Nipissing beach, * * " Why does he say Algonquin *or* Nipissing? In several previous papers Mr. Upham has made the same statement, viz.: that the Nipissing beach is the same as the Algonquin, and I have almost as many times pointed out the error of such a supposition. It seems to me that the time has come when the truth should be made clear. The Algonquin and Nipissing beaches are, in fact, absolutely distinct and separate throughout the whole area of their extent. The Algonquin beach always occurs at a higher level than the Nipissing. The former was probably made by a glacial lake held in by an ice barrier in the Ottawa valley; the latter was certainly not glacial and never had any connection or relation to any glacier whatever. The two beaches are not at all alike in their physical characteristics, nor in the strength of their development. Their planes are not parallel. Their attitudes are not similar except in the fact that they both rise towards the northeast. Their declivities are different and their minor deformations are not coincident either in area or amount. They represent two entirely separate stages of lake history and they record two different epochs of continental deformation. The supposition that they are one is entirely erroneous and inevitably vitiates our conception, not only of the lake history, but of the Pleistocene history of the northeastern quarter of the continent. My connection with the study of these two beaches may be briefly summarized as follows:

Random observations on the Nipissing beach began in the summer of 1890, but the recognition of its real significance and the naming of it did not occur until the autumn of 1893. Systematic tracing began and was well advanced that season. From all the observations made up to that time it was found that the beach was clearly identified for long continuous distances on the south shore of lake Superior; on both sides of the north end of lake Michigan; across the northwest end of lake Huron; at Sault Ste. Marie, Mackinac strait and at the Nipissing pass at North Bay, Ontario. It was doubtfully identified also at several other widely separated places.

In 1895 a large number of new observations were made, greatly extending the area of the identified beach. It was clearly made out along the north side of lake Superior from Port Arthur to Peninsula harbor and eastward from Sault Ste. Marie to Nairn, about half way to North bay. It was traced almost continuously southeastward from Mackinac to a point a few miles south of Harrisville where it passes under lake

Huron, and in the same fashion southwestward from Mackinac to Old Mission point in Grand Traverse bay where it passes under lake Michigan. In addition to this the fragment previously found at North bay was largely extended along the shores of lake Nipissing, the site of the old outlet was re-examined and some previous uncertainties were cleared up.

As to the character and identity of this beach I have already spoken plainly elsewhere. It is altogether the most remarkable littoral feature of the Great Lake region. It is a shore line well advanced towards old age. All the other beaches of the lakes are youthful in comparison. Except in the northern parts of the basins its elevation above the present lakes is so slight that its landscape effect is generally not striking, although it is often quite prominent. If the country were denuded of vegetation and this beach stood two or three hundred feet above the lakes I believe that in many places it would not fall far short of the grandeur of Gilbert's Lake Bonneville beaches. Instead of the slender spits and barrier bars of the Algonquin and other beaches, the Nipissing beach has what may be called barrier plains, made up of many, sometimes forty to fifty, massive beach ridges laid up one against the other. Many bays were entirely filled by these beach plains and others were cut off, so as to form small littoral lakes. Some of these plains are a mile to a mile and a half wide. In some instances the old deltas of the other beaches are large and conspicuous, but the constructive products of wave action have no comparison with those of the Nipissing beach.

My attention, however, has not been centered mainly on the Nipissing beach. On the contrary I should say that ten times as much time and laborious effort was given to the search for the Algonquin or "highest" beach as to the Nipissing. The observations on the latter have nearly always come in merely as incidents in the search for the former. The Nipissing beach was everywhere thrust upon my attention when I was searching for the Algonquin. I have made very few excursions with the special object of seeing the Nipissing beach. But it is generally so easy of access and is such a conspicuous and even obtrusive feature and is so easy to trace continuously that in the final summing up of all my field work I find that as much or more has been learned of the Nipissing beach than of the Algonquin. The latter beach, however, is always higher up on the coastal slopes and is generally difficult of access. Besides it has no such striking individuality of character as the Nipissing beach and in some regions, especially where there are other higher beaches, is likely to be confounded with them.

Spencer and Lawson have both done a large amount of systematic work on the Algonquin beach, although Lawson did not distinctly recognize its identity. But, I believe it is true that as the work stands to-day, I have covered a much wider territory than either of them, and my observations overlap both of their areas. As to the Nipissing beach, it happens that no one else has done any systematic work upon it. Random observations have been made by several others, but all these put together could hardly have led to a recognition of the real character and extent of this beach.

It is true, I believe, on the other hand, that Mr. Upham has never seen the Nipissing beach at all; nor has he seen the Algonquin beach to know it for a certainty. The only place where he has seen it at all is the vicinity of Duluth; but in the present state of our knowledge it is impossible to identify this beach with certainty in that part of the Superior basin. The gaps in the lines of tracing to the east and northeast are too wide and there are too many strong beaches resembling the Algonquin in that region.

Now in the face of these facts will Mr. Upham go on declaring that the Nipissing beach is the same as the Algonquin? Several other errors go along inevitably with this one and his whole scheme of the lake history is affected by them. If Mr. Upham's views are so extreme that he thinks I do not know an abandoned beach when I see it I am unable to see how he can use any of my facts. As it is, he uses some and rejects others. I fail to see how he can make any discrimination among my observations that is not purely imaginary on his part. The only way to do such a thing is for him to go into the field himself and verify or disprove my facts by his own observations. But he has not done this. I have found both beaches at the same locality in a large number of places and both were traced with substantial continuity along the same coast, in one instance, for nearly two hundred miles. If Mr. Upham will take the pains to visit any coast where both beaches occur, he will soon see his error. Or, if he cannot do this, let him revise his hypothesis in the light of a full and fair consideration of all the facts at hand. In either case his scheme of the lake history, as it has been several times set forth in public print during the last three years, will have to be abandoned. I would not venture to suggest what changes he should make nor what his story of the lake history should be. It is highly probable that some of the facts will bear a different interpretation from that which I have given them. But there are certain very important and well determined facts which cannot be misused or ignored if the truth is to be attained. The most comprehensive truth which it behooves Mr. Upham to consider is comprised in the statement that the Algonquin beach of lake Algonquin and the Nipissing beach of the Nipissing Great lakes are two entirely separate and distinct phenomena throughout. The elaboration of this statement in the study of each beach and its character is a very large theme, every step in the pursuit of which confirms and hightens the perception of the unique individuality of the Nipissing beach.

Mr. Upham also brings forward again the idea that the later stages of lake Warren spread over all four of the upper basins, including lakes Michigan and Superior. On this point I cannot speak with unconditional positiveness, as I do of the two great beaches mentioned above. All I can say is this, that I have many times made careful search on the coastal slopes above the Algonquin beach in various parts of the north for the beaches of lake Warren and I have never found a trace of them north of Alpena on the west shore of lake Huron. Nor did I find any beaches above the Algonquin beach north or east of Petoskey or north of Menominee in the basin of lake Michigan. During the past season I looked for these beaches on the slopes above the Algonquin shore line west and northwest of Alpena; about Bolton, Posen and Hagenville; on the high ridges south and west of Rogers City and near Ocqueoc and Onaway. From Indian River on the Michigan Central railroad I ascended the high drift hills to the southeast, up to hights two hundred and fifty to three hundred feet above the Algonquin beach and also drove over the hills east of Petoskey. All the beaches of lake Warren in the Erie basin and in the southern part of the Huron basin lie above the Algonquin beach. The highland slope between Petoskey and Alpena is a critical, test place for these beaches. They may be there. But I failed to find a sign of them, although they were made the particular object of search.

Mr. Upham's ideas of the lake history seem to have sprung from his hypothesis of the eastward retreat of the ice front, and ultimately from his belief in the unity of the Ice age. He has taken pains to explain this fully and to illustrate it by maps. So far as my observations in the north go, the predominant direction of striæ and of bowlder transportation and the positions of such fragments of terminal moraines as I have seen do not support this idea. One of the most convincing evidences on this point is that of the jasper conglomerate. The direction of transportation of these bowlders leaves no doubt as to the order of retreat for that area. They show that it was somewhat to the south of southwest across the central and north-western part of lake Huron. Again, striæ, bowlders and moraines show that at North bay and in the Mattawa valley the direction of ice motion was almost due south—generally from a point five to ten degrees east of north, but occasionally from a few degrees west of north. I would, therefore, question the very foundation of Mr. Upham's hypothesis. In order to bring the lake history into accord with his idea of the unity of the Ice age and the order of glacial retreat he has made assumptions which are clearly untenable because they do plain violence to a large body of well settled facts. There is nothing to be gained by anybody by persisting in a demonstrated error. If Mr. Upham could make himself acquainted with the facts at first hand, I feel perfectly certain that he would agree with me on them, however much we might continue to differ on matters of theory.

Fort Wayne, Ind., Apr. 29, 1896. F. B. TAYLOR.

BEACHES OF LAKES WARREN AND ALGONQUIN. The foregoing letter by Mr. Taylor seems to call for some defense of my opinions concerning the Laurentian glacial lakes, which were given in the April AMERICAN GEOLOGIST (pp. 238-241) and more fully in the paper and map there cited (Geol. and Nat. Hist. Survey of Minnesota, Twenty-third Annual Report, for 1894, and the Am. Jour. of Science for Jan., 1895). Mr. Taylor holds that the highest ancient shore lines, marked by distinct beaches and deltas, in the greater part of the lake Superior basin (excepting only the still higher shores of the Western Superior glacial lake, reaching from Duluth east to Marquette), and their eastern extension about the north part of lake Huron and of Georgian bay to lake Nipissing, are referable to Spencer's lake Algonquin. On the other hand, I hold, with Dr. A. C. Lawson, that the high beaches around lake Superior (excepting westward) belong to Spencer's lake Warren; and I believe that these shores are continuously traceable southward to the Arkona and Forest (or upper and lower Crittenden) beaches of lake Warren in its earliest and most thoroughly explored portion, namely, in the lake Erie basin.

Until the beaches thus differently correlated shall be traced continuously through the largely wooded country surrounding lake Huron, as I have continuously examined and mapped, with leveling, the beaches of lake Agassiz along more than a thousand miles, we cannot probably appeal to such demonstrative proof of either Mr. Taylor's or my view as to admit no further possibility of doubt. Meanwhile, in support of my interpretation of the published data, we have fifteen, or more, distinct marginal moraines mapped by Leverett and others in Ohio, Indiana, and southern Michigan, while I have mapped twelve such moraines in Minnesota, the most northern of these, passing by the south side of Vermilion lake, being probably contemporaneous, or approximately so, with the maximum extent of the Western Superior glacial lake. The general northwest to southeast outline of the boundary of the ice-sheet during its retreat is thus very definitely ascertained, in parallelism with the farthest limit attained by the ice accumulation and outflow on the plains of North and South Dakota, Nebraska, and Kansas, during the maximum Kansan stage of the Glacial period.

In the AMERICAN GEOLOGIST for March, 1895 (vol. xv, pp. 162-179), Mr. Taylor argues that the northward differential uplift of these beaches and of the lake Superior and Huron basins mainly preceded their eastward uplift; and this conclusion, with which (from other evidences) I concur, accords with the moraines in showing that the ice-sheet retreated first from the region of the upper Laurentian lakes and later from the lake Ontario and Ottawa basins. As soon as the glacial recession uncovered the land, it rose from its Late Glacial or Champlain depression.

The Algonquin beach about the south part of lake Huron, as traced by Spencer, I cannot therefore correlate, until continuity shall be demonstrated by continuous exploration and leveling, with the highest shore around the north part of this lake, on Mackinac island, and around the eastern two-thirds of lake Superior. That high water plane I refer to lake Warren, outflowing past Chicago to the Des Plaines, Illinois, and Mississippi rivers. When the glacial retreat subsequently opened an outlet from the Laurentian lake region past Rome to the Mohawk and Hudson, the ice-sheet still rested on the Ontarian and Laurentide highlands from near Toronto northward to the Ottawa basin and thence northeastward, as shown by the two glacial re-advances forming till deposits above the stratified and fossiliferous interglacial beds of Toronto and Scarboro'. Lakes Algonquin and Iroquois, the former outflowing to the latter along the present sites of lakes St. Clair and Erie and the Niagara river, date from the opening of the Rome outlet. Continuing northward, the Algonquin water plane of the southern part of the Huron basin, where it was first explored and named, must, according to the view which I hold, be represented by the very conspicuous Nipissing beach mapped by Taylor and Lawson from lake Nipissing to Duluth, with minor closely allied and nearly parallel water planes dependent on the variable direction and rate of contemporaneous epeirogenic uplifting and on the considerable filling of the area of the river and lake St. Clair with lacustrine sand, analogous with the great accumulation of beach and dune sand at the south end of lake Michigan.

One further remark may conclude the present discussion, namely, that the volume of the Niagara river, as I first pointed out in the AMERICAN GEOLOGIST, for July, 1894 (vol. xv, pp. 63-65), has been nearly as now during probably all its history, receiving the drainage of all the region of the upper Laurentian lakes. This will be accepted, as I suppose, by Mr. Taylor, not less than by me, whether the high shores of the northern Huron and Superior basins shall be found to belong to lake Warren or to lake Algonquin, if both, as we now alike think, were held in on the Ottawa region by the departing ice-sheet.

St. Paul, Minn., May 15, 1896. WARREN UPHAM.

RECENT PUBLICATIONS.

I. Government and State Reports.

University Geol. Sur. of Kansas, vol. 1, xii+320 pp., 31 pls. Topeka, 1896. A geologic section from Galena to Wellington, G. I. Adams; A geologic section from Baxter Springs to the Nebraska state line, Erasmus Haworth and John Bennett; A geologic section along the Neosho river from the Mississippi formation of the Indian Territory to Council Grove, Kas., and along the Cottonwood river from Wyckoff to Cedar Grove, M. Z. Kirk; A geologic section along the Missouri Pacific railway from the state line in Bourbon Co. to Yates Center in Woodson Co., John Bennett; A geologic section from the state line opposite Boicourt to Alma, principally along the Osage river, J. G. Hall; A geologic section along the Kansas river and its tributary, Mill creek, from Kansas City to McFarland, John Bennett; A section from Manhattan to Abilene, G. I. Adams; A geologic section from Coffeyville to Lawrence, Erasmus Haworth; A geologic section along the Central Branch of the Missouri Pacific railway, from Atchison to Barnes, E. B. Knerr; Resumé of the stratigraphy and correlations of the Carboniferous formation, Erasmus Haworth; Physiographic features of the Carboniferous, E. Haworth; The coal fields of Kansas, E. Haworth; Oil and gas in Kansas, E. Haworth; Surface gravels, E. Haworth; The Coal Measure soils, E. Haworth; A preliminary catalogue of the paleontology of the Carboniferous of Kansas, John Bennett.

II. Proceedings of Scientific Societies.

Bull. Minnesota Acad. Nat. Sci., vol. 4, no. 1, pt. 1, 1896. The Saint Peter sandstone, F. W. Sardeson: The fauna of the Magnesian series, F. W. Sardeson.

III. Papers in Scientific Journals.

Science, Apr. 17. Museum methods,—The exhibition of fossil vertebrates, F. A. Lucas: Museum methods,—On the arrangement of great paleontological collections, Charles Schuchert: The flow of the Connecticut river, Dwight Porter: American amber-producing tree, F. H. Knowlton; Current notes on physiography, W. M. Davis.

Science, Apr. 24. Relation of geologic science to education, N. S. Shaler: Ozarkian epoch—a suggestion, O. H. Hershey; Organic markings in Lake Superior iron ores, W. S. Gresley: The perogatives of a state geologist, C. R. Keyes.

Science, May 1. Notes on native sulphur in Texas, E. A. Smith; Current notes on physiography, W. M. Davis.

Science, May 8. Notes on certain undescribed clay occurrences in Missouri, G. E. Ladd: Note on a breathing gas well, H. W. Fairbanks; Current studies in experimental geology, T. A. Jaggar, Jr.

Am. Jour. Sci., May. Bearpaw mountains of Montana, W. H. Weed and L. V. Pirsson: Potomac River section of the Middle Atlantic Coast Eocene, W. B. Clark; Ischian trachytes, H. S. Washington: Crocoite from Tasmania, Chas. Palache.

Kansas Univ. Quarterly, vol. 4, no. 4, Apr. On the skull of Ornithostoma, S. W. Williston: A new species of Dinictis from the White River Miocene of Wyoming, E. S. Riggs.

IV. Excerpts and Individual Publications.

The origin and relations of central Maryland granites, C. R. Keyes. With an introduction on the general relations of the granitic rocks in the middle Atlantic Piedmont plateau, G. H. Williams. 15th Ann. Rept. U. S. Geol. Survey, pp. 651-740, pls. 27-48, 1895.

Some dykes cutting the Laurentian series in the counties of Frontenac, Leeds and Lanark, Ont., W. G. Miller and R. W. Brock. Canadian Rec. of Sci., 8 pp., pl. 3, Oct., 1895.

A variable sun the principal cause of the great Glacial period, Wm. Nims. 10 pp.; Advertiser print, Fort Edwards, N. Y., 1896.

Preliminary lists of the organic remains occurring in the various geological formations comprised in the S. W. quarter-sheet map of the eastern townships of the province of Quebec, H. M. Ami. Ann. Rept. Geol. Sur. Canada, new ser., vol. 7, pp. 113J-157J, 1896.

Some notes on the occurrence of uranite in Colorado, Richard Pearce. Read before the Colo. Sci. Soc., Sept. 9, 1895; 3 pp.

Geology of Woodbury county, Iowa, H. F. Bain. Iowa Geol. Sur., vol. 5, pp. 241-300, pl. 5, map, 1896.

PERSONAL AND SCIENTIFIC NEWS.

Dr. Joseph F. James has removed from Washington, D. C., to Hingham, Mass.

Niagara as a Timepiece is the title of an article by Dr. J. W. Spencer in *Appletons' Popular Science Monthly* for May.

Mr. C. D. Walcott, director of the U. S. Geological Survey, has been elected a member of the National Academy of Sciences.

The American Association for the Advancement of Science meets this summer at Buffalo, N. Y., beginning Monday, August 24th.

Dr. N. O. Holst, a Swedish government geologist, is travelling for a year in Australia. He expects to investigate, for a Scandinavian company, the gold deposits of West Australia.

Native Sulphur in Texas. Prof. Eugene A. Smith calls attention (*Science*, May 1) to some deposits of native sulphur about 40 miles northwest of Pecos City, Texas. Three localities are known where the sulphur has been discovered at or near the surface of the ground, and in each locality there appears to be sufficient material for profitable working.

The National Academy of Sciences met in Washington on April 20th to 25th under the presidency of Prof. Walcott Gibbs. The following papers relating to geological themes were presented: "The geological efficacy of alkali carbonate solution," E. W. Hilgard; "On the characters of the Otocœlidæ," E. D. Cope; "On the Pithecanthropus erectus from the Tertiary of Java," O. C. Marsh.

Organic Markings in Lake Superior Iron Ores. In *Science* for April 24th Mr. W. S. Gresley announces the discovery of traces of organic remains in fragments of iron ore from the Chapin mine at Iron Mountain, Mich. The material has been submitted to Messrs. H. S. Williams, Charles Schuchert, C. D. Walcott and C. R. Van Hise, all of whom are inclined to consider the markings as of organic origin, probably annelid trails.

Philadelphia Academy of Natural Sciences. Messrs. Persifor Frazer, Angelo Heilprin, Benjamin Smith Lyman and Theodore D. Rand have been appointed as the Committee on the Hayden Memorial Geological Award for 1896. Prof. Angelo Heilprin has been appointed to represent the Academy at the mining and geological millennial congress to be held at Budapest, Sept. 25th and 26th, in connection with the celebration of the founding of the kingdom of Hungary.

Geographic Range of Mississippi Valley Unionidæ. Mr. Charles T. Simpson, of the U. S. National Museum, contributes to the May *American Naturalist* an interesting discussion of the geographic range of many Unionidæ which have their best development in the Mississippi basin but also extend northeastward to the Laurentian Lake region and the Hudson river. Their dispersion is thought to have been facilitated by the streams outflowing from the glacial lakes of the St. Lawrence basin.

GEOLOGICAL SURVEY OF GREAT BRITAIN. We learn that Mr. J. R. Dakyns, M. A., who joined the Geological Survey in 1862, has just retired from the service. Mr. A. Strahan, M. A., has been promoted to the rank of Geologist on the English branch of the Survey, and Mr. C. T. Clough, M. A., is similarly promoted on the Scottish branch (in room of the late Hugh Miller). The two vacancies on the Staff of Assistant Geologists are filled by the appointment of Mr. Crosbee Cantrill. B. Sc., in England, and of Mr. E. H. Cunningham-Craig in Scotland. (*Geol. Magazine.*)

MR. WILLIAM LIBBEY, JR., professor of physical geography in Princeton University, expects to leave Princeton, with a party of six students, for the Hawaiian Islands on June 10th, the purpose being to study the botany, zoology and geology of this group of islands. Collections will be made along all of these lines for the Princeton Museum. Some physical work will be done in connection with a visit to the crater of Kilauea, if possible along the line of the determination of the lava temperature and the determination of the spectrum lines of the flames which accompany the lava outbursts.

ANOTHER LOG IN A LATE GLACIAL BEACH.

MR. OSSIAN GUTHRIE sends to the AMERICAN GEOLOGIST a sample of wood sawn from an oak log recently found in a Late Glacial beach of lake Michigan in the north part of Chicago, about fifteen feet above the present lake and nearly ten miles distant from the logs noted in our April number (page 259). This tree trunk rested on glacial till, and was covered along an extent of about forty feet by water-deposited fine clayey silt, by which it was protected so that its wood appears to differ from a modern log chiefly in its considerably blackened color. Mr. Guthrie announces his intention to make two gavels from this wood for the approaching national conventions. Its age is estimated as 7,000 years, more or less, being the same as the duration of the Postglacial or Recent period.

GEOLOGICAL MAP OF EUROPE
PUBLISHED UNDER THE AUSPICES OF THE INTERNATIONAL CONGRESS OF GEOLOGISTS.

Dr. Persifor Frazer, who secured the American subscribers to this map, writes as follows: "In a recent communication received by me from the 'Geographischer Verlagshandlung' of Dietrich Reimer (Höfer and Vohsen, Anhaltstrasse 12, Berlin,

S. W., Prussia) I am requested to advise all the subscribers on the list of the American Committee who may still desire the geological map of Europe, to address the above publishing house directly, stating that they were subscribers on the American list in 1888, and are therefore entitled to receive the complete map for the sum of eighty marks."

Dr. Frazer states that institutions and individuals may apply to him (1042 Drexel Building, Philadelphia) for those maps ordered for deceased subscribers, and that in this regard he will, other things being equal, give the preference to institutions.

FIFTEENTH ANNUAL REPORT, U. S. GEOLOGICAL SURVEY.

This report has just been delivered by the public printer. It is a handsome volume of 755 pages and 48 plates, and contains, besides the administrative reports of the director himself and of chiefs in charge of work, the following special papers:

"Preliminary Report on the Geology of the Common Roads of the United States," by Prof. N. S. Shaler; "The Potomac Formation," by Prof. L. F. Ward; "Sketch of the Geology of the San Francisco Peninsula," by Andrew C. Lawson; "Preliminary Report on the Marquette Iron-bearing District of Michigan," by Prof. C. R. Van Hise, W. S. Bayley and H. L. Smyth; and "The Origin and Relation of Central Maryland Granites," by Dr. C. R. Keyes, with an "Introduction on the General Relations of the Granitic Rocks in the Middle Atlantic Piedmont Plateau," by the late Prof. G. H. Williams.

From these titles it is evident that the paper of most popular interest is the first one, on roads, by the versatile Harvard professor. He treats of the history of American roads, the methods of using stone in road-building, the relative value of road stones, their distribution, sources of supply, etc., and thus makes a timely contribution to a subject which is receiving special attention in all parts of the country.

This is the last report made by major J. W. Powell as director of the Survey, who until recently has had charge of the work, under different organizations, for twenty-five years.

NEW YORK ACADEMY OF SCIENCES.

The section of geology and mineralogy held its regular meeting April 20th, President J. J. Stevenson in the chair.

The first paper of the evening was by MR. JOHN D. IRVING on "*The Stratigraphy of the Brown's Park Beds, Utah.*" The observations on which the paper was based were made by Mr. Irving the past summer while spending a week in Brown's park, together with Dr. J L. Wortman and his expedition from the American Museum of Natural History, New York. Mr. Irving first sketched the topography and geology of the Green River basin and the Uinta mountains. He showed the location of the Brown's Park beds and described their unconformable position upon the Uinta sandstone and the Green River shales. He next outlined the views that had already been published regarding their stratigraphical relations, especially those of Clarence King and S. F. Emmons of the 40th Parallel Survey, who referred them to the Pliocene, and those of C. A. White of the United States Geological Survey, who referred them to the Eocene. Mr. Irving stated that careful search failed to reveal any fossils except a few fragments of bone, which were in such a state that Dr. Wortman considered them to be not earlier than the Pliocene. Mr. Irving then described the Lodore cañon and explained the formation of the lake in which the Brown's Park beds were deposited as due to the Pliocene elevation of the Uinta sandstone that forms the wall of the Lodore cañon. When this was cut down by the river the lake disappeared and depositions ceased. He, therefore, corroborated the original determinations of King and Emmons. The paper will appear in full in the Transactions.

The second paper of the evening was by Prof. C. H. Smyth, Jr. on "*The Origin of the Talc Deposits near Gouverneur, N. Y.*" Dr. Smyth first described the geological surroundings of the talc and showed that it occurs along a series of belts in limestone walls and that the previously published statement that it occurs in gneiss is incorrect. By means of microscopic sections he traced its development by the alteration of tremolite in largest part and from enstatite to a less degree, the changes in both having been affected through the agency of water and carbonic acid. The talc occurs in two forms,—a scaly variety, or talc proper, and a fibrous variety, or agalite. He was unable to determine whether the original rock was a basic intrusive or a siliceous magnesian limestone. The full paper will appear in the School of Mines Quarterly for July, 1896.

The third paper of the evening was by Prof. H. P. Cushing and was entitled "*Are there Pre-Cambrian and Post-Ordovician Trap Dykes in the Adirondacks?*" Field work in Clinton county, N. Y. had convinced the writer that there were two periods of dyke intrusion in the Adirondacks. The first yielded the porphyries or bostonites, the camptonites and non-feldspathic dykes, which cut the Paleozoic strata up to and through the Utica slate. These dykes are chiefly limited to the shores of lake Champlain both in New York and in Vermont. They practically lack diabase. The second set are limited to Archean rocks, are much more numerous and are practically all diabase. One hundred and sixteen dykes in all are known in Clinton county; sixteen belong to the first series, while the remaining one hundred belong to the second. The latter have been found in the gneisses in many cases very near the contacts with the Potsdam sandstone, but in no case have they been found penetrating the sandstone. The same relations have been noted by Smyth at the Thousand islands.

Prof. Cushing, therefore, urged that these dykes should be considered a separate series of rocks that had been formed subsequently to the metamorphism of the crystalline rocks and before the deposition of the Potsdam sandstone. The paper will appear in full in the Transactions.

J. F. Kemp, Sec'y.

Geological Society of Washington.

At the 43d meeting, held in Washington, D. C., April 22, 1896, communications were presented as follows: "A new laccolite locality in Colorado and its rocks," by Mr. G. K. Gilbert and Mr. Whitman Cross; "The origin of some mountain scarps," by Mr. M. R. Campbell.

Mr. Gilbert described a laccolitic locality discovered last summer in southern Colorado. Dakota and older rocks are bent into a dome with a hight of 1,000 feet and a width of 5 miles. Many dikes traverse this and two laccolites are exposed in partial section. The horizons of intrusion are more than 600 feet below the base of the Dakota. The date of intrusion is approximately indicated as Eocene or late Cretaceous. The intruded rock is more basic than is ordinarily found in laccolites and is much more easily disintegrated by weathering. The neighboring sandstones and those portions of neighboring shales which have been baked by the intrusions resist erosion better than the igneous rocks, so that the laccolites find topographic expression in valleys instead of hills. A mass of altered sandstone, protecting a pedestal of shale and igneous rock, stands prominent above the country, constituting the crest of Twin butte, the most conspicuous landmark of the region.

The rocks of the laccolite and dikes were described by Mr. Whitman Cross. The rock of the laccolite and of most of the dikes is a basic syenite porphyry, in which the ferro-magnesian silicates, augite, biotite and olivene, exceed the feldspathic constituent. Augite is the predominant silicate. These rocks are allied to a large series from the plains of Colorado and New Mexico, to be described by Mr. Cross.

Mr. M. R. Campbell discussed the origin of the eastward facing scarp of the Blue ridge throughout North Carolina, which has been attributed (1) to the action of sea waves on an elevated coast, (2) to the normal erosion of a broadly uplifted peneplain, and (3) to deformation produced by radial movements in the crust of the earth. The first and second theories he regarded as obsolete or insufficient. The third theory seems to offer the best explanation, but deformation alone could hardly produce the present scarp; there seems to have been modifying conditions which have not heretofore been formulated, but which were probably the immediate cause of the scarp production.

No radial movement is known to have occurred in the Appalachians of sufficient intensity to produce so steep a scarp, but if, during a period of baseleveling, a slow monoclinal uplift occurs, the portion of the region which is beyond the influence of the uplift will remain at base-level, whereas in that portion in which the movement is at a maximum the process of baseleveling will be interrupted, producing a very different succession of topographic forms. There will be an intermediate zone in which the forces of elevation and degradation will be balanced against each other.

If the movement is relatively rapid the peneplain will encroach but slightly upon the uplift. If the movement is slow the peneplain will encroach to a much greater extent not only along the streams, but in the inter-stream areas also. The result of this encroachment is to accentuate the slope produced by the uplift, and if the movement is extremely slow the slope will become a scarp.

If this hypothesis is correct the peneplain which caps the Blue ridge is continuous with the Piedmont plain at a very short distance from the foot of the ridge, but the intermediate, or sloping, portion of the old peneplain is almost completely removed by more recent erosion along the zone of tilting.

In the vicinity of Roanoke, Va., this uplift turned toward the north and crossed the Appalachian valley. In this portion of its course similar results were produced, but the rocks are not hard enough to preserve the scarp as they do further south. In crossing the Appalachian valley this uplift protected the basin of New river against the encroachment of the Atlantic streams, which otherwise would, doubtless, have captured its headwaters. In this region also some of the tilted portion of the older peneplain is probably preserved in an intermediate level which some observers have classed as a distinct peneplain.

It seems probable that in other regions local uplifts have occurred during the continuance of periods of extensive baseleveling, and if so similar forms have probably been produced. W. F. Morsell.

INDEX TO VOL. XVII.